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ADVANCED INTERNAL CARGO SYSTEM CONCEPT DEMONSTRATION AND EVALUATION

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January 1982

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Prepared for

APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
Fort Eustis, Va. 23604

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report represents the development effort to configure, design, and fabricate an "add on" Internal Cargo Handling System for the CH-47 helicopter. The principal objective of this effort was to provide a practical flightworthy cargo system capable of installation without major airframe modifications to the helicopter. Also, the system had to handle Air Force 463L pallets and 40- by 48-inch warehouse pallets. This Laboratory concurs with the results of this effort and the recommendations in this report.

A program is planned to employ this hardware in an Army aviation unit for test and evaluation. This will provide the necessary knowledge to insure a low-risk entry into full-scale development. Mr. J. F. Tansey of the Aeronautical Systems Division served as project engineer for this effort.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the design and development activity resulting in an "add-on" cargo handling system for the CH-47 helicopter. Design activity was initiated as a result of cargo handling problems encountered in the European Theater. The Applied Technology Laboratory at Fort Eustis, Virginia, designed and fabricated a mock-up of an internal cargo handling system that demonstrated a practical approach for an add-on system for the CH-47.

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An evaluation of this mockup, together with the results of an investigative field trip to the European Theater, led to the requirements definition for the cargo handling system.

The cargo handling system can be installed in a CH-47 helicopter with no modifications to the primary structure. The system can handle 463L pallets, warehouse pallets and special munitions. The system includes forward and aft barriers to minimize tiedown requirements, ramp extensions to allow easy fork-lift loading and a fuselage levelling system. Functional tests of the system resulted in minor modifications to the original hardware. The modified hardware has been successfully installed and demonstrated in a CH-47C and a CH-47D helicopter.

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PREFACE

This report describes the design, fabrication, fit and function efforts in the development of an internal cargo system for the CH-47 helicopter. The work was performed under contract DAAK51-80-C-0006, directed by the Applied Technology Laboratory, U. S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia.

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INTRODUCTION

The Boeing Vertol CH-47 Chinook Helicopter has been in service with the U.S. Army for approximately twenty years. The helicopter has been configured with an internal cargo handling system consisting of an aft loading ramp, a cargo haul-in winch, vehicle treadways and cabin floor tiedown fittings. While this arrangement has been satisfactory for many of the missions conducted by the CH-47, expanding mission roles have revealed severe limitations when loading palletized cargos and special munitions.

During the service life of the CH-47, many local adaptations have been made to utilize available roller tracks to speed up cargo handling. These adaptations have been jury-rigged systems that have not made full use of the helicopter capabilities. Several studies were also undertaken during this time, resulting in recommendations for sophisticated systems; however, no purpose designed hardware was produced.

As a result of the renewed interest in internal cargo handling systems due to cargo handling problems in the European Theater, the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, designed and fabricated a mock-up of an internal cargo handling system. This effort demonstrated a practical approach for an "add-on" system and eventually led to the design and fabrication contract for flightworthy demonstration hardware as described in this report.

BACKGROUND

Two activities were significant in initiating the requirements for this program. The first was the mock-up design and fabrication by the Applied Technology Laboratory, the second was a joint Army/Industry investigative trip to determine system requirements from the user in the field.

INTERNAL CARGO SYSTEM MOCK-UP

In May 1977 the Applied Technology Laboratory (ATL), U.S. Army Research and Technology Laboratories (AVRADCOM), received a request from the Commander in Chief, U.S. Army, Europe (USAREUR) for development of a cargo helicopter with internal rapid-loading and off-loading capabilities.

In response to this requirement, ATL designed and fabricated a functioning mock-up of a cargo handling system in a CH-47 fuselage. The system was designed to handle Air Force 463L pallets, Army 40-inch X 48-inch wood pallets and munitions such as TOW and Hellfire. A full description of this activity is available in Reference 1.

The mock-up demonstrated the feasibility of a system design that required a minimum of change to the basic aircraft and achieved compatibility with the 463L pallet system.

INVESTIGATIVE FIELD TRIP TO ESTABLISH REQUIREMENTS

In late May 1979, a team including representatives of ATL, CH-47 PMO, TRADOC and Boeing Vertol embarked on a fact-finding trip to the European Theater. The purpose of the trip was to determine requirements for an Internal Cargo Handling System for CH-47 helicopters.

The team contacted the following units:

a. USAREUR AVN Office, Heidelberg

b. 205th Med. Hel. Co. - Finthen Army Airfield

c. 295th Med. Hel. Co. - Coleman Barracks, Mannheim

d. 4th Transportation Brigade - Oberurisel

e. 60th Ordinance Group - Meisau Army Depot

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1. Tansey, John F. "CH-47 Helicopter Internal Cargo Load and Restraint System Mock-up Study." Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, November 1978, USARTL-TN-32, AD A064207.

f. 59th Ordinance Group/72nd Ordinance BH - Meisau Army Depot

g. US Army ATCO - Rhein Main AFB

h. 180th Med. Hel. Co. - Schwabiach Hall

i. Ministry of Defence, London, United Kingdom

The trip report, DRCPM-CH47M-T, is summarized below.

The frequent movement of special weapons as internal loads throughout the European theater highlights the need for a CH-47 cargo handling system. The current loading methods are cumbersome and time consuming, often resulting in aircraft being volume limited rather than weight limited. The ability to accommodate the U.S. Air Force 463L pallet system will enable the CH-47 to intergrade with the ALOC operation in Europe.

The following criteria was established as an objective for a CH-47 internal cargo system.

a. Rail/Roller spacings should be based on accommodating both 463L (88" x 108") and standard 4-way entry wood NATO (40" x 48") pallets, including permissible overhangs (2").

b. Nominal stow positions for NATO pallets to consist of two rows 40" x 48" dimension in longitudinal direction.

c. Configuring non-standard loads (Nuclear projectiles, etc.) for compatibility with the ICHS by placing them on plywood or pallet base is acceptable.

d. Provisions for longitudinal restraint of individual loads during load/unload operations should be integral to rail/roller assemblies, and be rapidly engaged/disengaged.

e. The length of the ramp extension should be based on space available to rotate from stow to operational positions and ability to accept a side approach placement of M-480 and M-480E1 cans on the ramp extension by fork lift.

f. Vertical restraint features of outboard rails on both the ramp and the ramp extension should be capable of accommodating ground level loading/unloading.

g. In its stowed position, ramp extension should provide for access to the tiedown rings on the ramp.

h. Ramp extension surface should provide for a permanent anti-skid surface.

i. Provisions for securing the ICHS to the aircraft floor must be integral to or permanently affixed to rail/ roller sections.

j. Ramp and ramp extension outriggers should be designed for maximum 463L weights (10,000 lbs) and should be positioned to provide for stable support during load/ unload operations.

k. Stowing the forward barrier in overhead cabin when not in use is acceptable. Provisions for attaching aft barrier to rail/rollers and for stowing when not in use is a critical design feature.

l. System design must provide for access to center hook (when not fully loaded).

m. Aircraft structural design is based on 8g tiedown factors with the final decision on forward restraint criteria (crashworthy restraint) after appropriate trade studies.

n. Most common GSE available is the Fork Lift Truck (FLT), and the ICHS as proposed should be predicated on use of FLT at LZ's and most DZ's.

o. Ground level unloading using 4 wheel taxi away from loads is required.

p. Consideration should be given to incorporation of a fold-down seat for the crew chief integral to the aft barrier/ramp.

q. Consideration should be given to safely allow movement of personnel within the cabin, i.e., so that rollers will not become a safety hazard.

The report concluded that a dedicated internal cargo handling system was required for each CH-47 helicopter, with the ability to mix internal cargo and troops, and recommended the continued development of an interim system.

BASIC SYSTEM REQUIREMENTS

The contract statement of work reflected the following design criteria:

INTERNAL CARGO LOAD AND RESTRAINT SYSTEM DESIGN CRITERIA

1. The installed system shall be as light as practical.

2. System installation and operation shall not require any modification to aircraft primary flight critical structure.

3. The system shall be designed so that it can be rapidly installed in and/or removed from the aircraft by not more than four personnel under the supervision of the crew chief (MOS 676 20) within a target of 20-30 minutes.

4. The system shall accommodate the rapid loading/unloading and restraining of a wide range of cargo types without causing pallet damage. Within respective aircraft payload capabilities, door and compartment dimensions, cargo types shall include, but not necessarily be limited to:

a. Loaded Air Force 463L cargo system pallets HCU-6/E, HCU-12/E - MIL-P-27443E (USAF).

b. Loaded standard Army/NATO 4-way entry wood pallets with allowable overhang.

c. TOW missile crates (L58" x W39" x H51").

d. HELLFIRE missile crates (L70" x W40" x H34").

e. Palletized munitions.

5. The system shall be designed to prevent damage to aircraft structures, fittings, seats and other appurtenances and components which could be caused by the cargo being loaded or unloaded or by ground handling equipment.

6. In addition to paragraph 4, above, the system shall be compatible with:

a. Mixed cargo and passenger operations.

b. Mixed wheeled and palletized loads.

7. System restraint criteria:

Forward - per MIL-STD-1290
Aft - 5 G
Lat - 1.5 G
Up - 2 G

8. The system shall have provisions for cargo loading and unloading with and without ground handling equipment.

9. The system shall have provisions for safe loading and unloading operations.

10. For medium lift helicopters, the installed system shall have provisions to ensure reasonable access to all existing 5,000-lb and 10,000-lb tiedown fittings on aircraft BL+44 and BL-44.

11. The system shall provide for quick and easy access to utility hatches.

12. The system shall be secured to the cargo floor utilizing existing tiedown fittings.

13. Rollers, where used, shall be designed to be compatible with pallet configurations referenced in paragraph 4, above, to the maximum extent possible. They shall also accommodate a range of pallet bottom surface conditions (warped boards, etc.).

14. System components which may require periodic removal/ replacement shall be designed to facilitate such operations.

15. For the medium lift helicopter, the system shall have provisions to ensure tail ramp support for loads in excess of 3,000 lbs but not greater than 10,000 lbs.

16. The system shall accommodate installed troop seats for dual mission capability.

17. Any aircraft modification shall be capable of being accomplished at the aviation unit maintenance level.

18. The system shall have provisions for loading internal cargo up to the aircraft maximum payload limit without adverse flight performance characteristics due to cargo-induced vibratory loads."

During the course of concept and preliminary design this criteria was modified in the area of weight and restraint criteria in order to achieve schedule and fiscal limitations. Areas that will permit significant weight reductions by material or design approach change are identified in the Conclusions and Recommendations section of this report.

PRELIMINARY DESIGN

The preliminary design addressing the established criteria looked in detail at several specific areas of the design concept:

1. The requirement for fuselage leveling
2. The system integration with the existing cabin floor isolation arrangement
3. The application of crashload criteria of MIL-STD-1290
4. The need for center guides for warehouse pallets
5. The type of roller to be used.

FUSELAGE LEVELING

The ability to level the fuselage as an aid to the loading of heavy pallets was an obvious advantage but the real need was not so apparent. At the outset of the program the addition of such a potentially complex system needed to be fully justified.

The CH-47 cabin floor has an aft slope of approximately 2 degrees when unloaded, and approximately 3 degrees when fully loaded with a uniformly distributed load. With the ramp approximately level and the ramp extensions in position, the floor geometry is as shown in Figure 1. Consideration of the geometric change when a 10,000-lb pallet was passed over the aft end of the cabin resulted in a geometry as shown in Figure 2, due to the compression of the aft landing gear oleo and tires.

The "valley" created between the ramp and cabin presented the conclusive argument for the leveling system. Without leveling, a 10,000-lb 463L pallet would require a longitudinal force of between 1,500 lb and 2,000 lb, depending on the roller friction, to move up the fuselage slope and present high unit loads on each roller as the pallet bridged the "valley". Figure 3 shows the geometry of the leading edge/roller interface. These forces were higher than acceptable for manually installed pallets in the cabin and imposed a severe penalty on roller design.

While it is recognized that the majority of loads would be less than 10,000-lbs the problem of the "valley" remains for all significant loads. As the objective of the program was to provide systems for field evaluation, the decision was made to include fuselage leveling and structure a field test plan that would evaluate the impact of this subsystem.

CARGO FLOOR ISOLATION

The CH-47 cabin floor is supported by a series of elastomeric isolators designed to prevent excessive cockpit vibration with

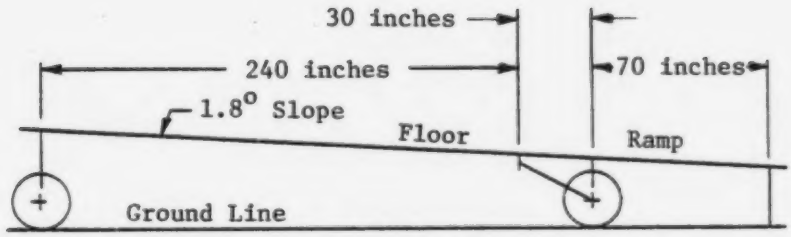

FIGURE 1. EMPTY FLOOR GEOMETRY.

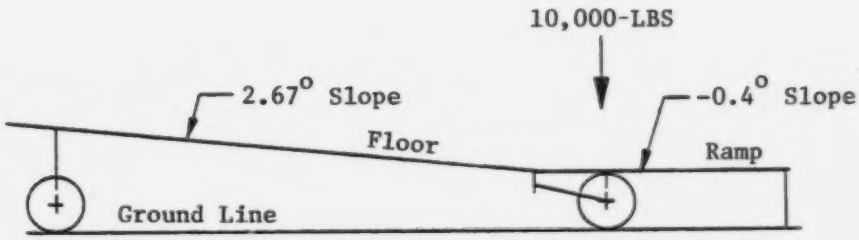

FIGURE 2. FLOOR GEOMETRY WITH 10,000-LB PALLET.

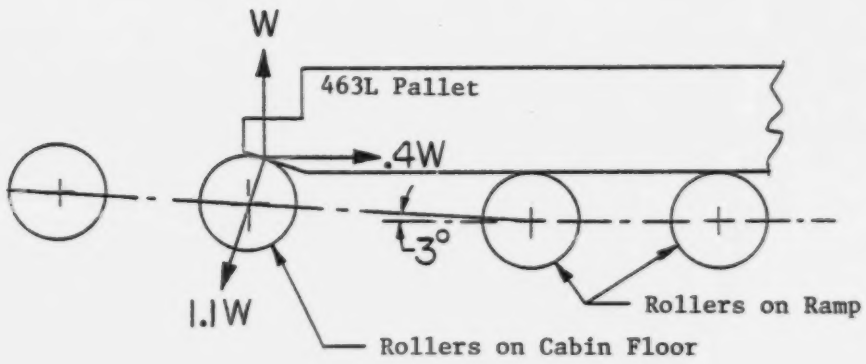

FIGURE 3. GEOMETRY OF RAMP/FUSELAGE JOINT.

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heavy internal loads. A primary mission of the helicopter is to transport wheeled vehicles which result in the isolators being arranged with closer spacing in the outboard, treadway, areas. An objective of the cargo system is to transport 40-inch x 48-inch warehouse pallets side-by-side along the fuselage, requiring close attention to isolator loading to avoid bottoming the isolators.

A study of the isolator characteristics determined that 40-inch x 48-inch pallets could be loaded to 2,100 lb without requiring discriminatory loading arrangements or causing the isolation to bottom. A review of possible palletized munition loads showed that only four possible loads would exceed 2,100 lb; these four loads ranged from 3,700 to 2,260 lb. These pallets may be carried in the extreme forward area or the extreme aft area of the cabin, where the floor is not isolated. Should it be necessary to carry these pallets on the isolated portion of the cabin floor then they will be spaced such that the sum of the weight of any two longitudinally adjacent pallets does not exceed 4,300 lb. This restriction was considered to be acceptable, hence enabling the floor system to be designed without heavy and inconvenient lateral spreader bars as used in the concept mock-up (Reference 1).

The 88-inch x 108-inch 463L system pallet may be fully loaded without compromising the isolation system.

MIL-STD-1290 CRASH LOAD CRITERIA

An initial objective of the program was to increase the crash load capability of the cargo restraint system. The basic CH-47 has a cargo restraint criterion of 4g forward, 2g lateral, 2g aft, 4g vertically down and 2g vertically up; this criterion is consistent with the airframe design. The CH-47 structure has demonstrated inherently good crashworthy characteristics throughout its service life, and a review of accident data did not reveal any significant problems due to defective cargo restraint. Based upon this review there did not appear to be a driving requirement to increase the restraint capability and in the interests of program economics, MIL-STD-1290 criteria were not imposed upon the system. However, during the design phase consideration was given to a possible future incorporation of a load attenuating system. The restraint barrier design takes advantage of the floor tiedown capability, resulting in a forward interia factor of between 4 and 6g, depending on the type of pallet being transported.

WAREHOUSE PALLETS

In July 1979, Boeing Vertol conducted a series of tests to determine the need for guide surfaces for warehouse pallets. Two 20-ft lengths of commercial roller/rail assemblies were mounted on heavy plywood panels and arranged such that lateral angles could be introduced by shims under the wood panels. A commercial

wood pallet of similar dimensions to the standard NATO pallet was loaded to 3,300 lb and moved along the rollers. Forces required to initiate and sustain movement were measured, along with lateral movement of the pallet. The rails were progressively shimmed to represent lateral angles up to 5 degrees. There were no tracking problems; however, on removing the load, inspection of the pallet showed that the lower surface in contact with the rollers had grooved such that it ensured lateral alignment with the rollers.

The pallet was rebuilt using hard wood for the lower boards. The tests were repeated and poor tracking was exhibited, without introducing any lateral angles. It was obvious that lateral guides were essential, and they needed to be robust in order to resist the high contact load generated.

TYPES OF ROLLERS CONSIDERED

The selection of the roller configuration was made early in the program, based upon a simple trade study that reviewed four types of rollers/shafts (see Figure 4).

Type I consisted of a solid nylon roller running on a Teflon coated steel sleeve. This configuration had been tested at the Boeing Commercial Airplane Company in Seattle to establish an order-of-magnitude friction coefficient.

Type II consisted of an aluminum sleeve roller with nylon inserts on each end running on a steel pin. This configuration is used on the CH-46 helicopter floor.

Type III consisted of a commercial high hysteresis wheel type of roller with integral ball bearing. The roller assembly is clamped between steel channels. These rollers were used for the mockup built by ATL (Reference 1) and for the pallet guide rail tests, previously described.

Type IV consisted of an aluminum sleeve roller with integral ball bearings on each end running on a steel pin, as used by the Boeing Commercial Airplane Co. in their commercial aircraft.

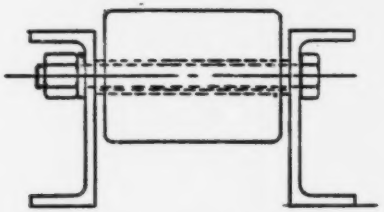
The factors considered in this trade study included overall height, weight, friction (force) and cost. Availability and durability were also considered, although these parameters were not quantified. Table 1 ranks the four rollers and shows that the Type I configuration of a solid nylon roller, running on a Teflon plated shaft, would be the best compromise for this program.

OTHER SIGNIFICANT CONSIDERATIONS

In order to comply with the requirement for no changes to the primary aircraft structure the decision was made to use the existing 10,000 lb tiedown provisions to install the outboard guides and rollers into the cabin. These tiedowns were not

TYPE I

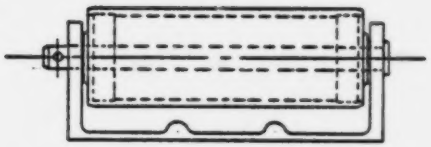
NYLON ROLLER, TEFLON COATED STEEL SLEEVE, 5" SPACING



1. Ceiling Height Loss: 2.25 inches
2. Weight per 10 ft. Segment: 18 lbs.
3. Force Factor: 10.5
4. Cost Factor: 1.5

TYPE II

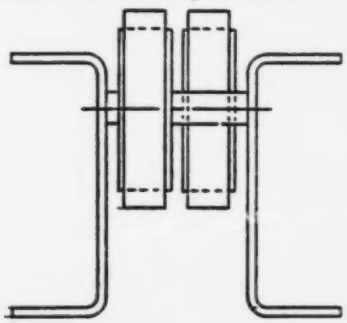
A02S4101-1 ROLLER, ALUM.SLEEVE,NYLON BEARINGS
5" SPACING (CH-46 SYSTEM)



1. Ceiling Height Loss: 1.5 inches
2. Weight per 10 ft. Segment: 14 lbs.
3. Force Factor: 20
4. Cost Factor: 1.8

TYPE III

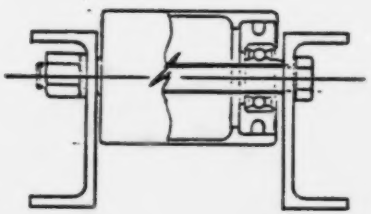
DOUBLE ROW ROLLERS,HIGH HYSTERESIS WHEEL,
1-1/2" STAGGERED SPACING, (PALLETFLO,KORNYLAK)



1. Ceiling Height Loss: 3.5 inches
2. Weight per 10 ft. Segment: 69 lbs (shipping wt.)
3. Force Factor: 20
4. Cost Factor: 1.0

TYPE IV

ROLLER,ALUM. SLEEVE,BALL BEARINGS, 5" SPACING



1. Ceiling Height Loss: 2.25 inches
2. Weight per 10 ft. Segment: 22 lbs.
3. Force Factor: 12
4. Cost Factor: 1.7

FIGURE 4. ROLLER STYLES CONSIDERED.

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TABLE 1. ROLLER CONFIGURATION TRADE STUDY.

	Type I	Rank	Type II	Rank	Type III	Rank	Type IV	Rank
Height Loss	2.25	2	1.5	1	3.5	4	2.25	2
Weight Factor	18	2	14	1	69	4	22	3
Force Factor	10.5	2	20	3	20	3	1.9	1
Cost Factor	1.5	2	1.8	4	1.0	1	1.7	3

Height Loss: Inches from floor to top of roller.

Weight Factor: Weight of 10-ft section.

Cost Factor: Based on approx. cost of a 10-ft section, with III as base ($187)

Force Factor: Based on tests conducted at Seattle and B.V. (force required to move a steel plate between two rollers with 600-lb load).

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replaced, as a review of the existing cargo manuals showed that this would have a minimal impact on the tie down of other types of cargo. Two 5,000-lb straps can replace the 10,000-lb tiedown where this is currently specified. All the 5,000-lb fittings used to retain the system have replacement rings as part of the system.

In order to simplify the barrier system design and fabrication, the decision was made to use structurally identical designs for both the forward and aft barriers.

DETAIL DESIGN DESCRIPTION

The complete cargo system consists of four major subsystems: cabin floor, ramp and ramp extension, barrier system, and fuselage leveling system. An analysis of flight critical items was conducted and is reported in Reference 2.

The cabin floor system consists of four rows of rollers, located at left and right BL38.8 and left and right BL5.25; side guide rails to suit the 463L pallets, located at left and right BL44; removable center guiderails for warehouse pallets located at left and right BL2.5; and provisions for the multiposition barrier restraint system as shown in Figure 5.

The side guiderails, located at left and right BL44, are retained by attaching to eight 2 blade fittings that replace the 10,000-lb tiedown rings along left and right BL44 at STA 240, STA 320, STA 400 and STA 482, and to two 5,000-lb tiedown rings along left and right BL44 at STA 160 as shown in Figure 6. Replacement tiedown fittings, attached to the guiderail, are provided as shown in Figure 7.

The roller channels located at left and right BL38.8 rest directly on the upper surface of the cabin floor and are attached to the left and right BL44 guiderails with multi-leaf hinges as shown in Figure 6. This allows the roller channels to articulate with the isolated cabin floor while the guiderails remain in a fixed position. In addition, this feature allows the roller channels to be stowed by pivoting the roller channels vertically and attaching them to the replacement tiedown fittings with straps, increasing the available wheel track width on the cabin floor. It also provides a stowage area for the removable warehouse center guiderails, between the multileaf hinges and the floor, when they are not in use.

The roller channels located at left and right BL5.25 are attached to each other by beam assemblies to form roller channel assemblies. The roller channel assemblies rest directly on the upper surface of the cabin floor and are secured to the floor by 16 cargo tiedown rings along BL0. This method of securing the roller channel assemblies provides for a pivoting tiedown replacement at each existing tiedown ring along BL0 as shown in Figure 8.

Roller assemblies are built in five successive sections joined by quick-release pins, permitting the roller section over the external cargo hook to be removed for hook access.

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2. Dennis M. "Stress Analysis, Advanced Internal Cargo System, CH-47 Helicopter," report number D210-11839-1, Boeing Vertol Company, May 1981.

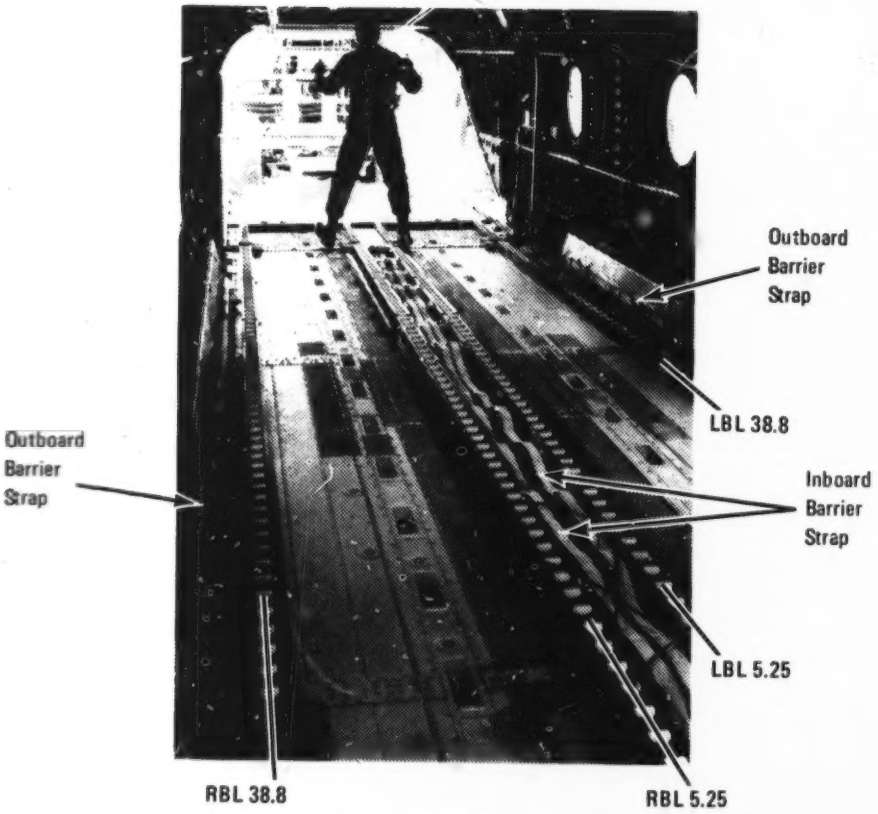

FIGURE 5. CABIN FLOOR, LOOKING AFT.

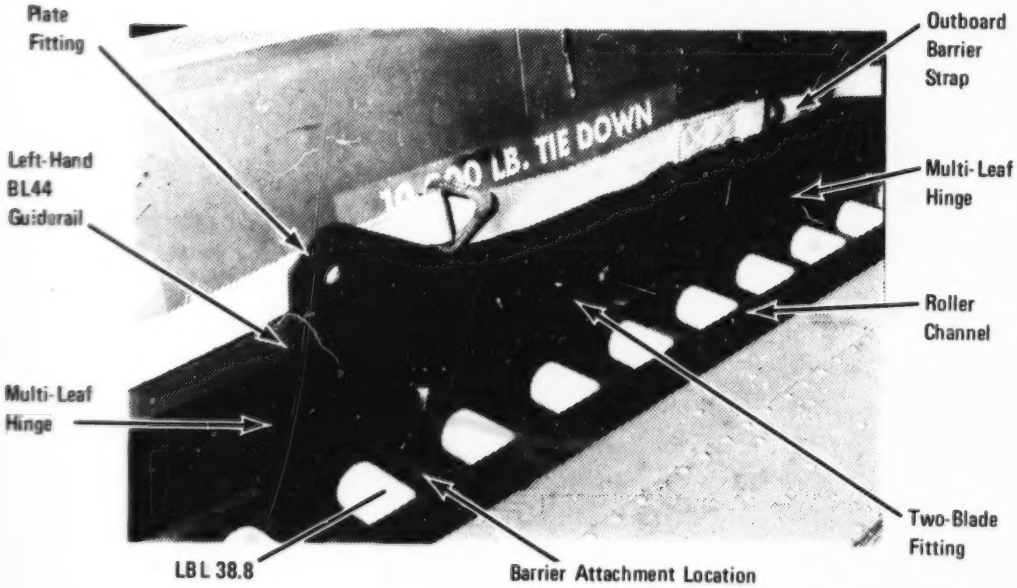

FIGURE 6. DETAIL, OUTBOARD ROLLERS.

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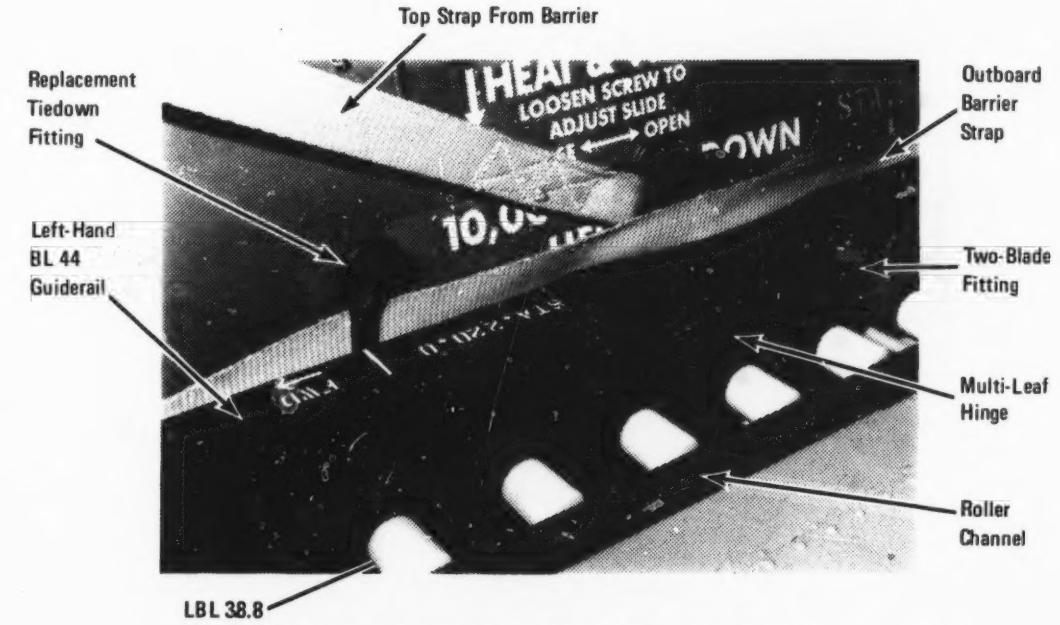

FIGURE 7. DETAIL, OUTBOARD ROLLERS.

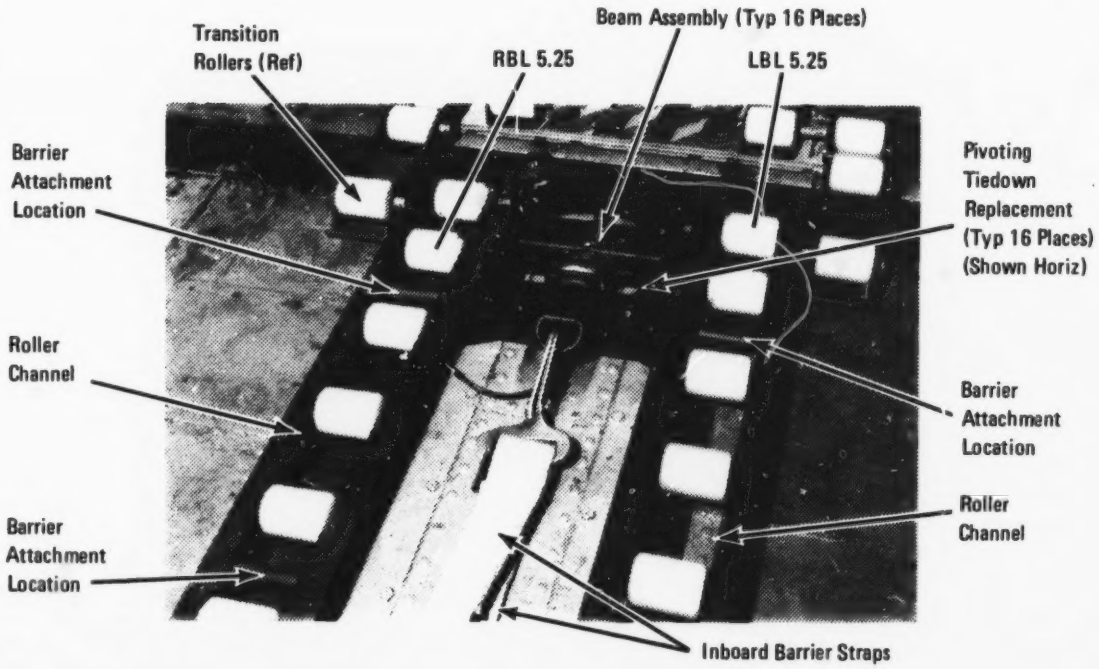

FIGURE 8. DETAIL, CENTER ROLLERS.

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The ramp system consists of a combination of guiderails, located at left and right BL44, three ballmat panels and four roller channels. The three ballmat panels cover approximately the aft two-thirds of the ramp floor. The forward one-third of the ramp floor consists of roller channels which are in line with the cabin system roller channels as shown in Figures 9 and 10.

The side guiderails, located at left and right BL44, are attached directly to the ramp floor by using ten existing bolt locations along each guiderail.

The roller channels located on the forward portion of the ramp along left and right BL38.8 rest directly on the upper surface of the ramp floor and are attached to the left and right BL44 guiderails with hinge sections as shown in Figure 9. This allows the roller channels to be temporarily stowed in a vertical position to increase the wheel track width available on the ramp floor.

The aft portion of the ramp is prepared for installation of the ballmat panels by installing the left and right base assemblies which are held in place by the left and right BL44 guiderails and by utilizing two existing screw locations to bolt through the aft inboard edge of each base assembly. The center ballmat panel is located on top of the left- and right-hand base assemblies and attaches with one bolt at each corner. The outboard ballmat panels are placed on top of the base assembly to complete the installation (see Figures 9 and 10). The outboard ballmat panels have transfer balls on one side and an anti-skid surface on the other. The transfer balls provide for alignment of warehouse pallets with the cabin rollers, while the anti-skid material provides a surface on which troops can walk and wheeled vehicles may be loaded. In flight the outboard ballmat panels are retained by positioning the pivoting guides inboard as shown in Figure 10. The center roller assembly is installed on the forward portion of the ramp and is held in place by attaching to the base assemblies and by utilizing two existing bolt locations to bolt through the forward end of the center roller assembly.

When loading pallets, the pivoting guides are located in the outboard position to provide a lead into the cargo area for the pallet. When unloading the 463L pallets, the pivoting guides are located in the outboard position. While unloading warehouse pallets the pivoting guides are located in the inboard position to aid in alignment of warehouse pallets with the ramp extension rollers. For the unloading of 463L pallets in the taxi dump mode, transition rollers are provided at four locations between the forward edge of the ramp floor and the aft edge of the cabin floor so that an acceptable roller pitch is maintained, as shown in Figure 12.

Rollers are added to the existing GFE ramp flippers, as shown in Figure 10, to extend the rolling surface beyond the aircraft structure to allow for the use of ground support equipment in the loading and unloading of palletized cargo.

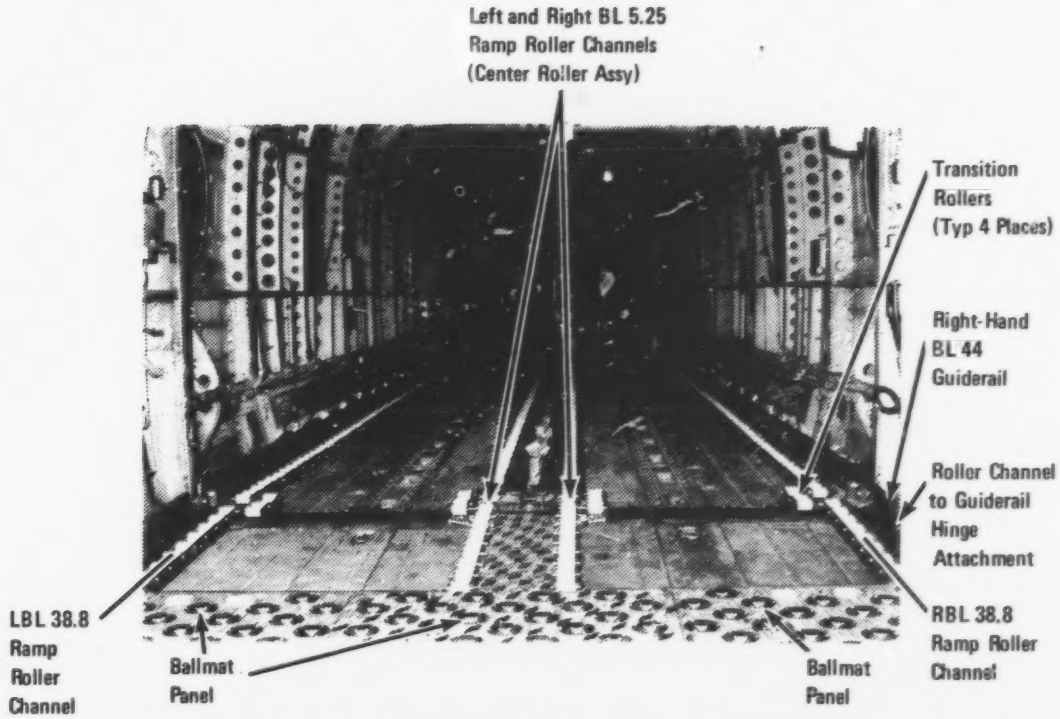

FIGURE 9. CABIN FLOOR, LOOKING FORWARD.

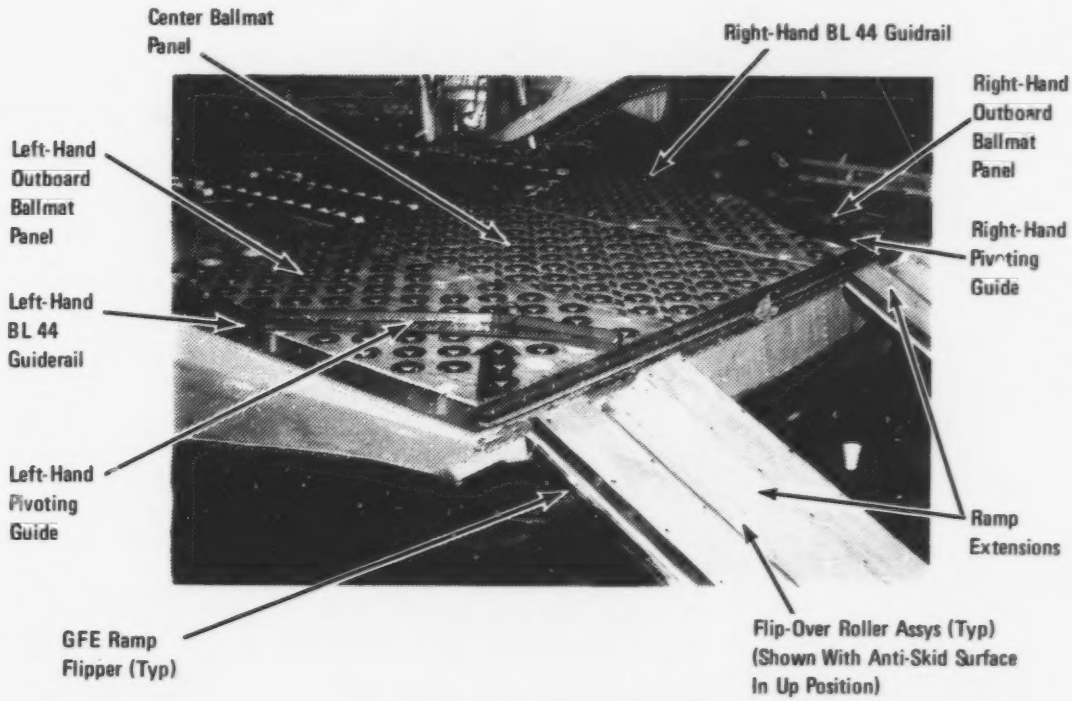

FIGURE 10. RAMP DETAILS.

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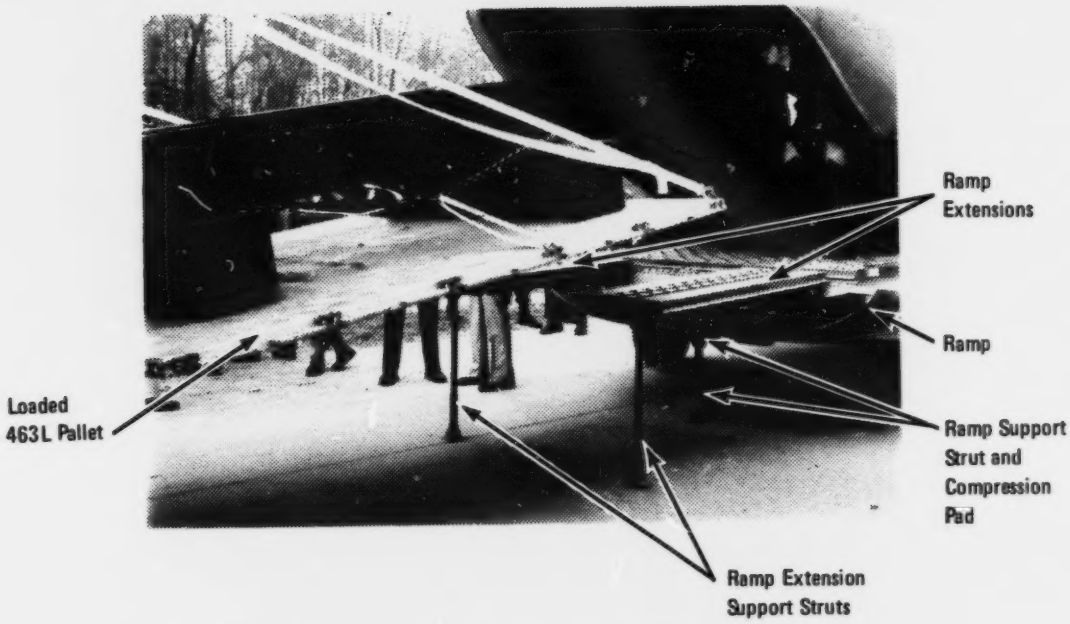

FIGURE 11. RAMP AND RAMP EXTENSION.

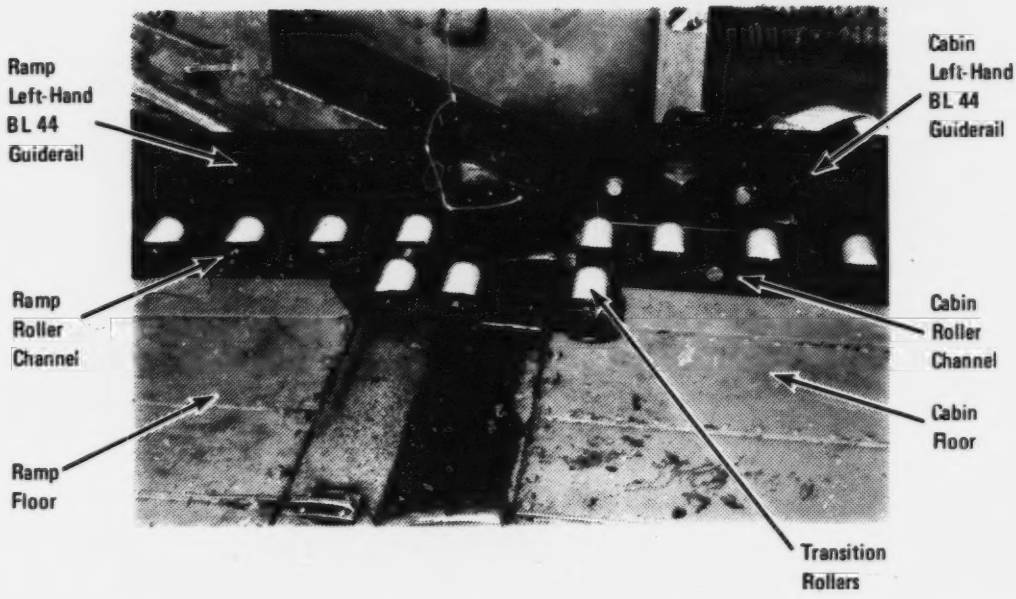

FIGURE 12. RAMP/CABIN JUNCTION.

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The original design of the two ramp extensions consists of wood shims, anti-skid material and flip-over roller channel assemblies which are bolted through the GFE ramp flippers as shown in Figure 10. The rollers are mounted in channel section rails which in turn are attached to a plate coated with anti-skid material. When loading or unloading cargo the roller channels are positioned with the rollers facing up. When loading or unloading wheeled vehicles or troops the roller channel assembly is removed from the extension, flipped over and reinserted into the extension with the anti-skid coating facing up as shown in Figure 10. (See the Design Changes section for the redesign of the ramp extensions.)

For the support of the aft edge of the ramp when positioned for level loading, while handling fully loaded 463L pallets, an aluminum compression pad and a telescoping support strut are provided. The overlap area of the telescopic tube contains a series of holes that allow discrete adjustment of the ramp height to compensate for terrain variation. In a similar manner, telescoping support struts are provided for the support of the aft edge of the ramp extensions when positioned for level loading as shown in Figure 11.

The barrier system provides forward and aft restraint of the cargo. 463L pallets will require no other restraint since the cabin guiderails, along left and right BL44, are configured to retain the pallet (both vertically and laterally). Warehouse pallets will require retention for vertical and lateral loads. The forward barriers may be positioned at either STA 160 or STA 236, with the CG limitations of the aircraft governing which position is selected. The aft barriers are multiposition. The first attachment location is at STA 260 with additional attachment locations, aft of STA 260, at approximately 12-inch increments, with the last attachment location at STA 480. The selected aft barrier location will be the first available attachment location aft of the load.

The outboard barrier straps are attached to the cabin, left and right BL44 guiderails, by connecting the forward end to the plate fitting mounted on the guiderail at STA 169 and the aft end to the 'D' ring mounted on the guiderail at STA 481.78 as shown in Figure 15.

The inboard barrier straps are attached to the cabin center roller channels along BL0 by connecting the forward ends to the swivel fitting, located between the center roller channels at STA 164, and the aft ends to the 'D' ring, mounted on the beam assembly at STA 481.78 as shown in Figure 16.

The forward barriers are assembled as shown in Figure 13 and installed in the roller channels, at the appropriate STA, by latching each stanchion foot to the barrier attachment location as shown in Figure 14.

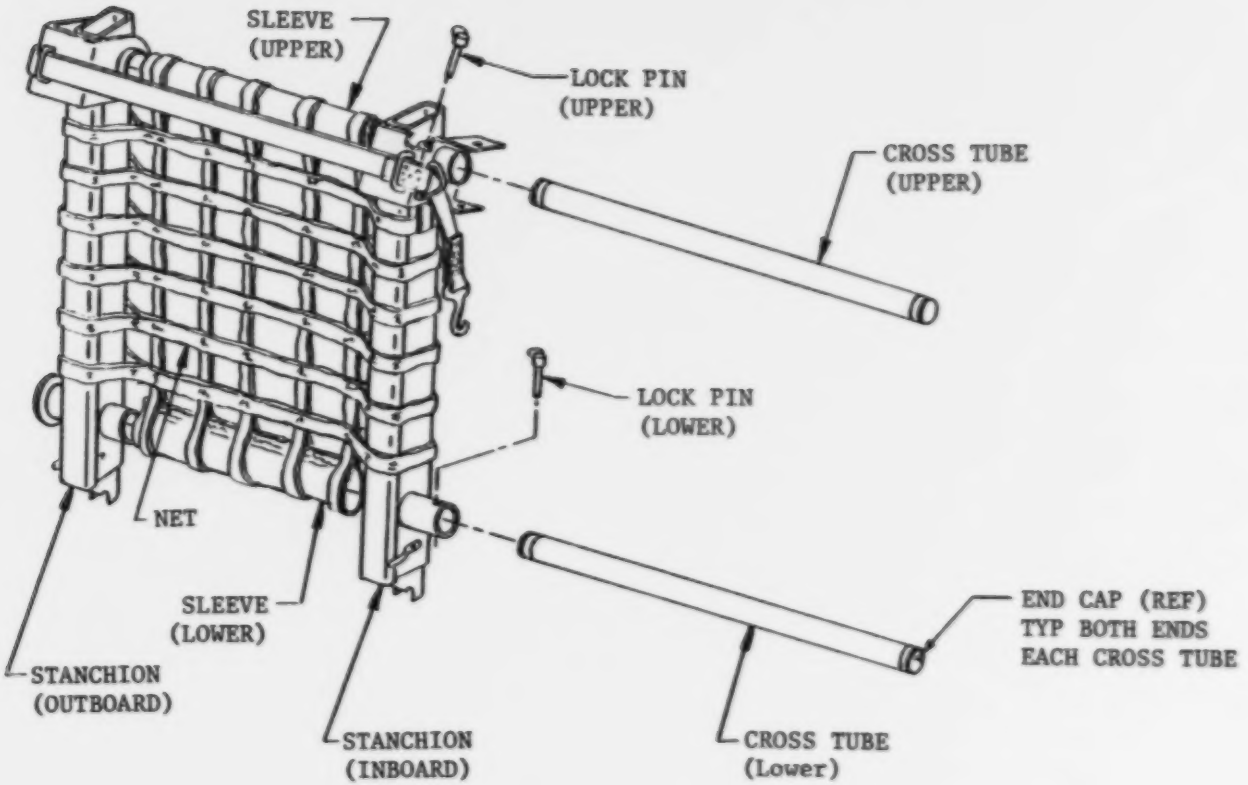

FIGURE 13. BARRIER ASSEMBLY

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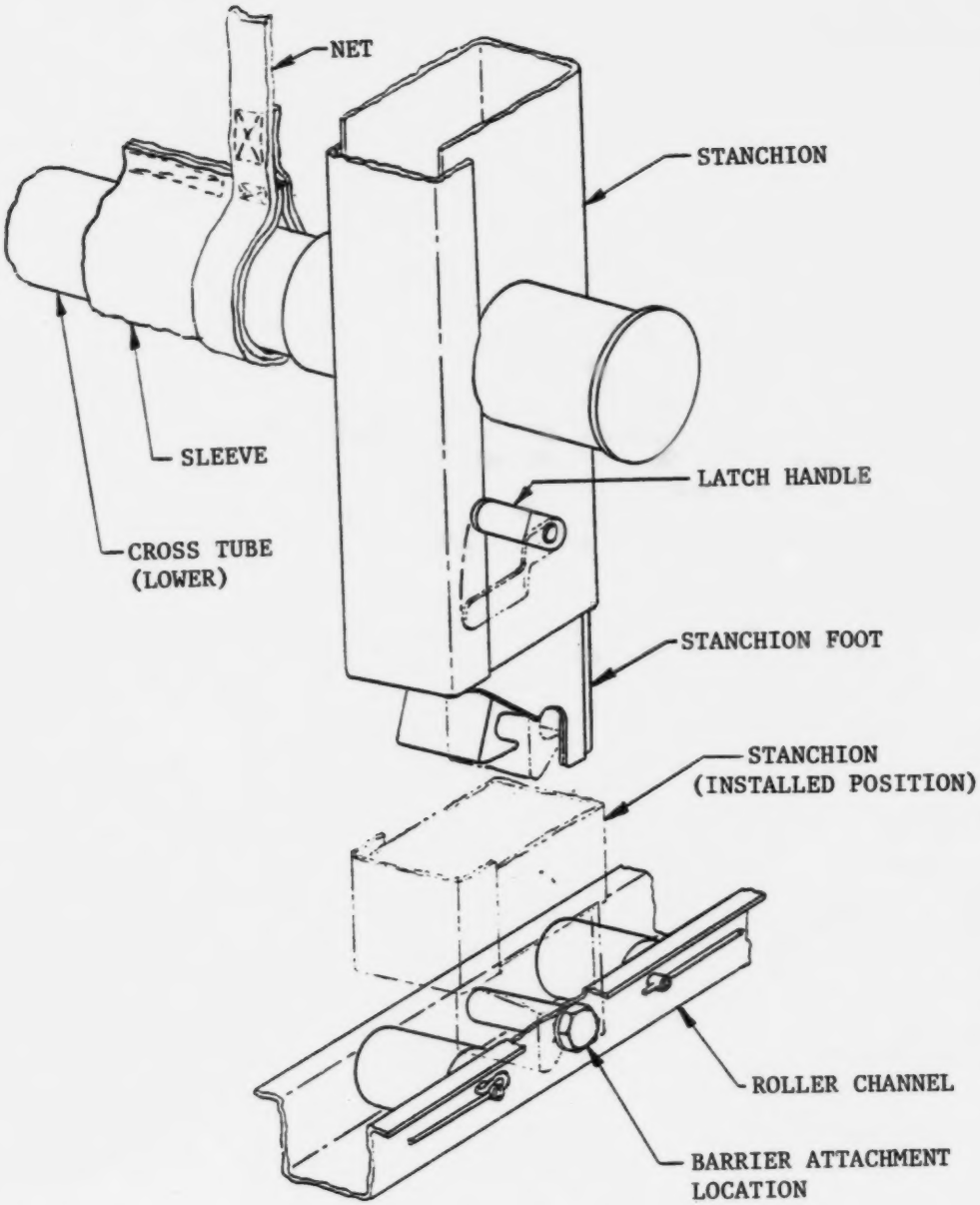

FIGURE 14. BARRIER/ROLLER RAIL INTERFACE.

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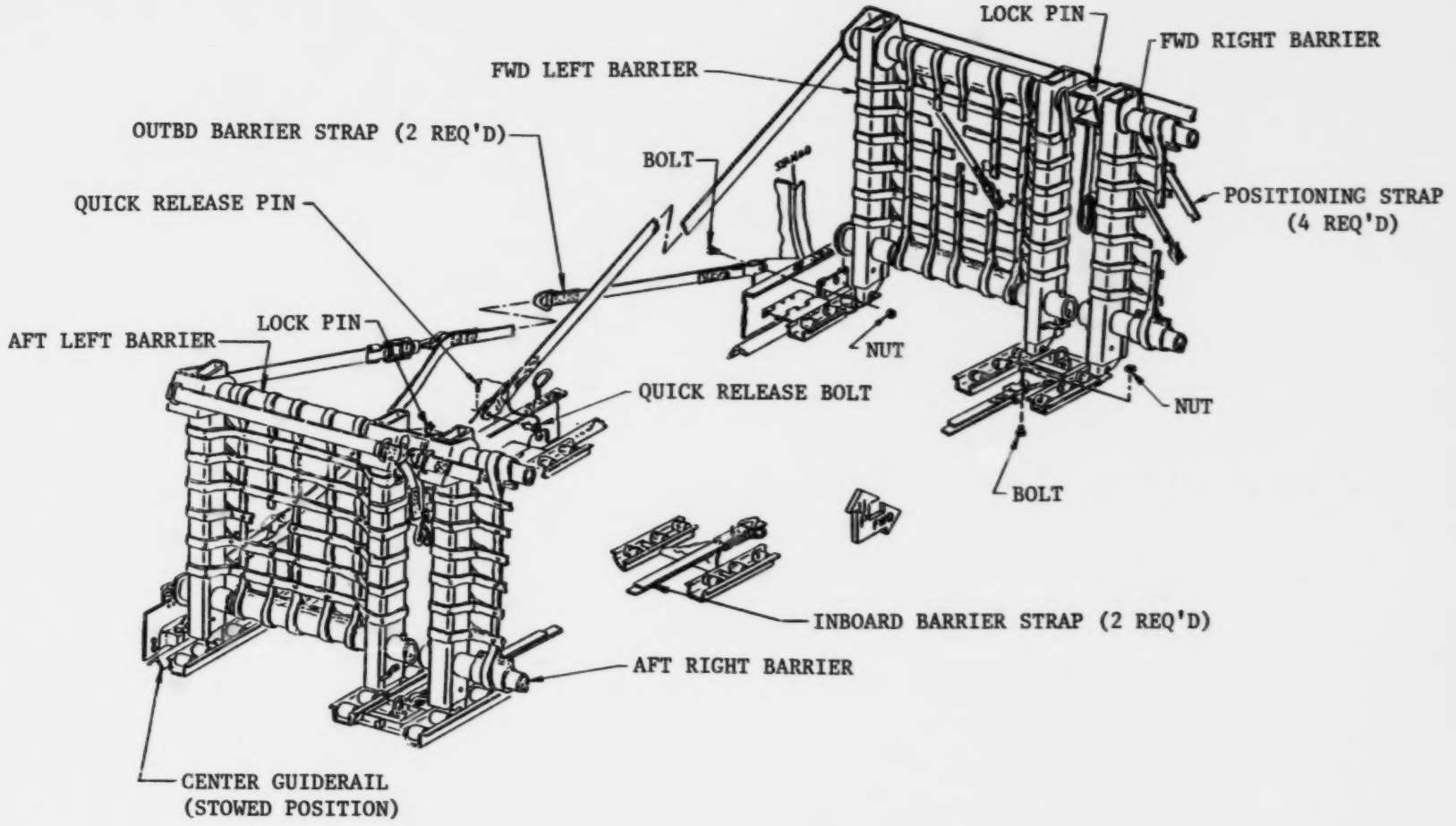

FIGURE 15. BARRIER SYSTEM 463L PALLET MODE.

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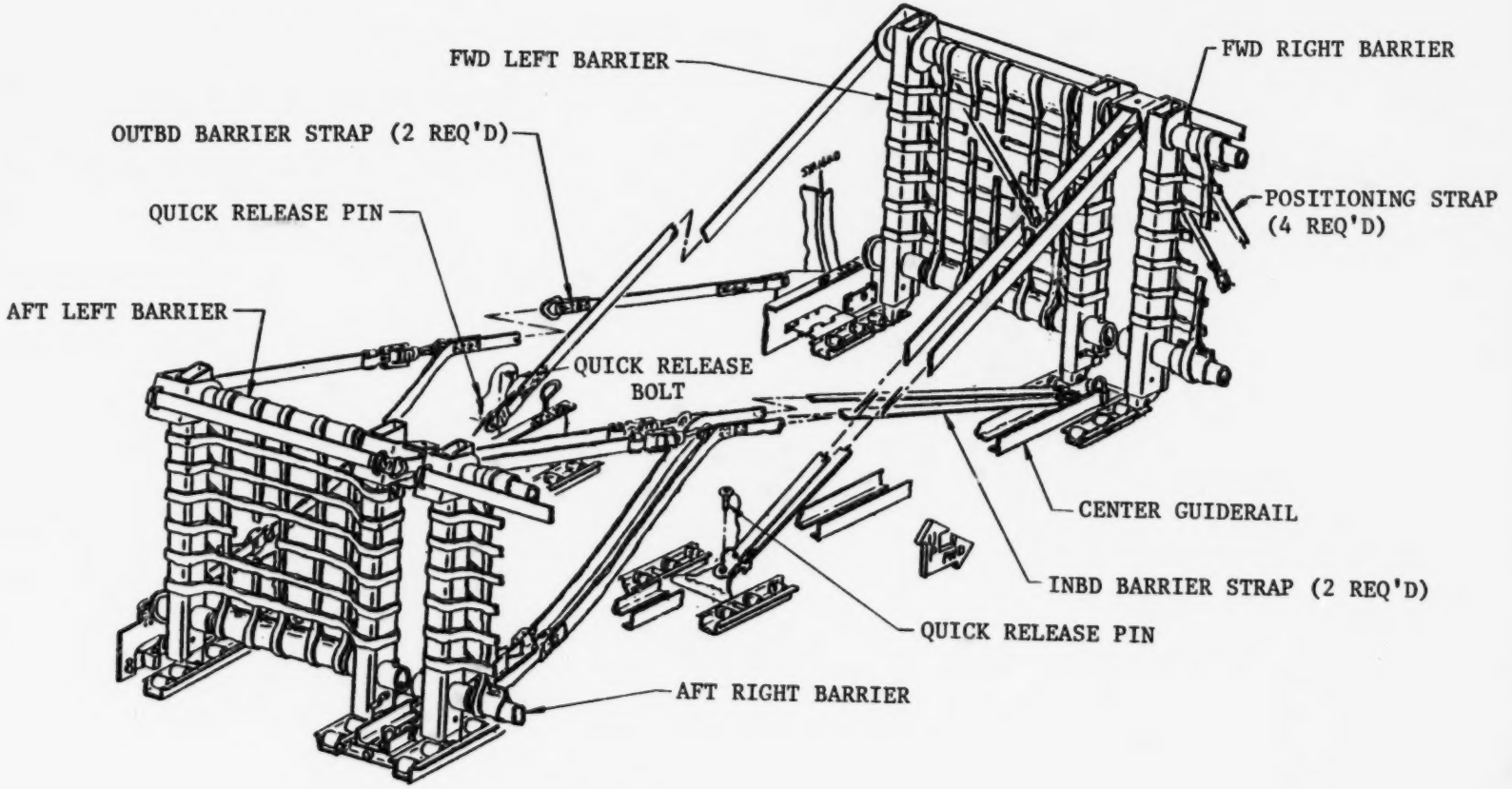

FIGURE 16. BARRIER SYSTEM WAREHOUSE PALLET MODE.

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The straps located at the top of the barriers are attached to the plate fittings mounted on the left-and right-hand BL44 guiderails at STA 232.5 as shown in Figure 15. Positioning straps are used to connect the upper forward face of the stanchions to the 5,000-lb tiedown rings, just forward of the stanchions, to maintain barrier stability until the cargo has to be loaded and positioned against the barriers as shown in Figure 15.

The aft barriers are assembled as shown in Figure 13. After cargo has been loaded, the aft barriers are installed in the roller channels at the first available barrier attachment location as shown in Figure 14. The straps located at the top of the barriers are attached to one of the 'D' rings on the outboard barrier straps as shown in Figure 15.

When using the barriers in the 463L mode, the left- and right-hand upper barrier straps are connected to each other as shown in Figure 17. The completed 463L mode installation is as shown in Figure 15.

In the warehouse pallet mode, in addition to connecting the straps located at the top of the forward barriers to the plate fittings, as previously defined, the straps are connected to the swivel fitting located between the center roller channels along BL0 at STA 272 as shown in Figure 16. In addition to connecting the straps located at the top of the aft barriers to the outboard barrier straps, as previously defined, the straps are connected to the 'D' rings attached to the inboard barrier straps as shown in Figure 16. The completed warehouse pallet mode installation is as shown in Figure 16.

The fuselage leveling systems provide for a known volume of oleo fluid to be added to each of the aft landing gear struts for full extension. The system is self-contained and utilizes manual pumps to transfer the fluid. On completion of loading, the fluid volume is returned to the transfer cylinder by the aircraft weight after the appropriate valve is opened. Closing this valve returns the landing gear to its normal configuration. The leveling system is packaged as two modules. In the original design each module is mounted on the engine work platform surface as shown in Figure 19. Access to the pump is obtained by opening the engine work platform doors.

The module attaches to the engine work platform upper surface with six bolts through the platform and stowes, flat, on the upper surface. To prepare for operation, a quarter-turn fastener is released at the forward end. The module is then pivoted into a vertical position until the hinge pin holes in the hinge half mounted on the module are aligned with the hinge pin holes in the hinge half mounted on the platform. A pin is inserted through the holes to lock the module in a vertical position. A hydraulic connection is made to the aft landing gear by a valve connected

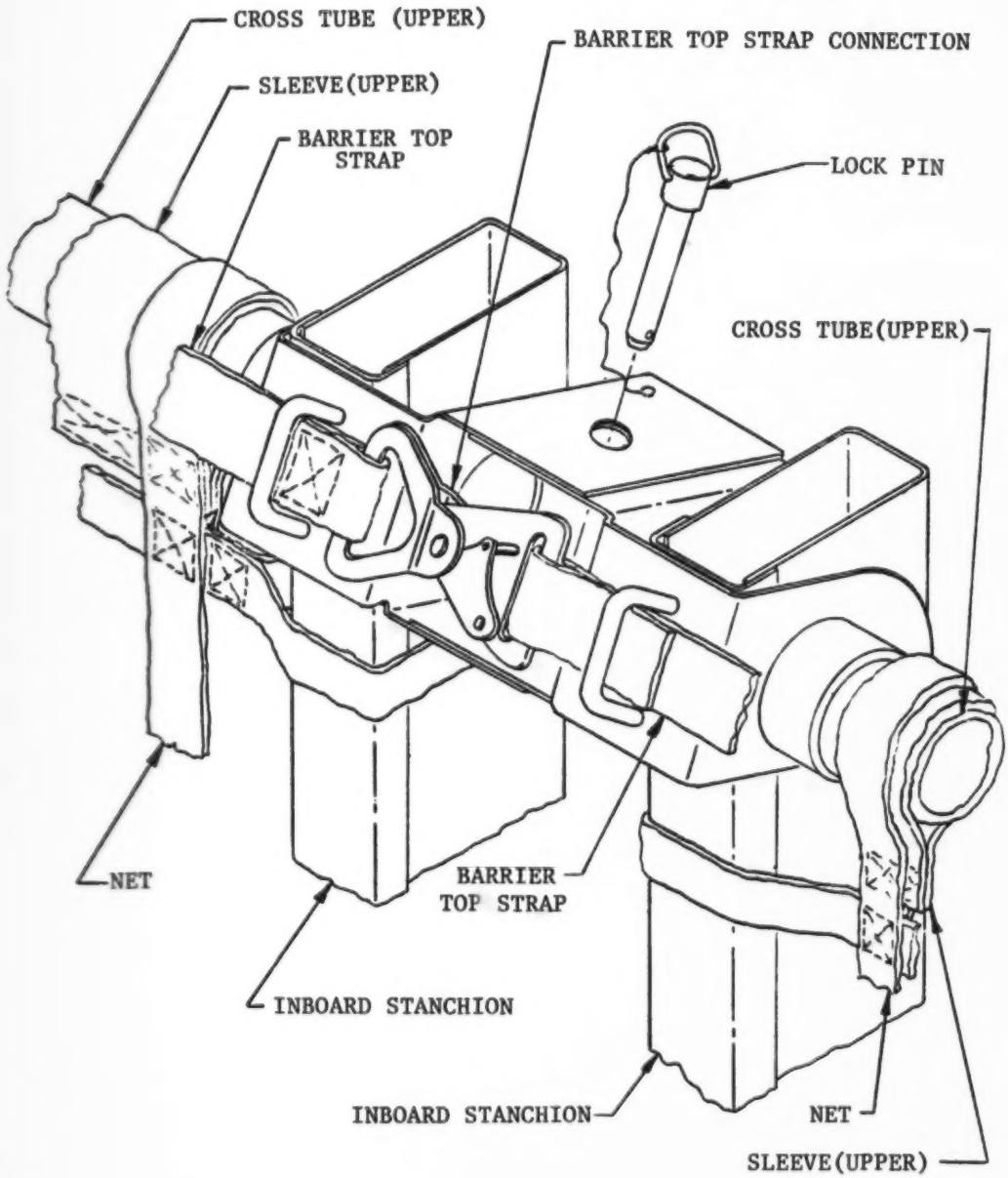

FIGURE 17. BARRIER JUNCTION,463L PALLET MODE

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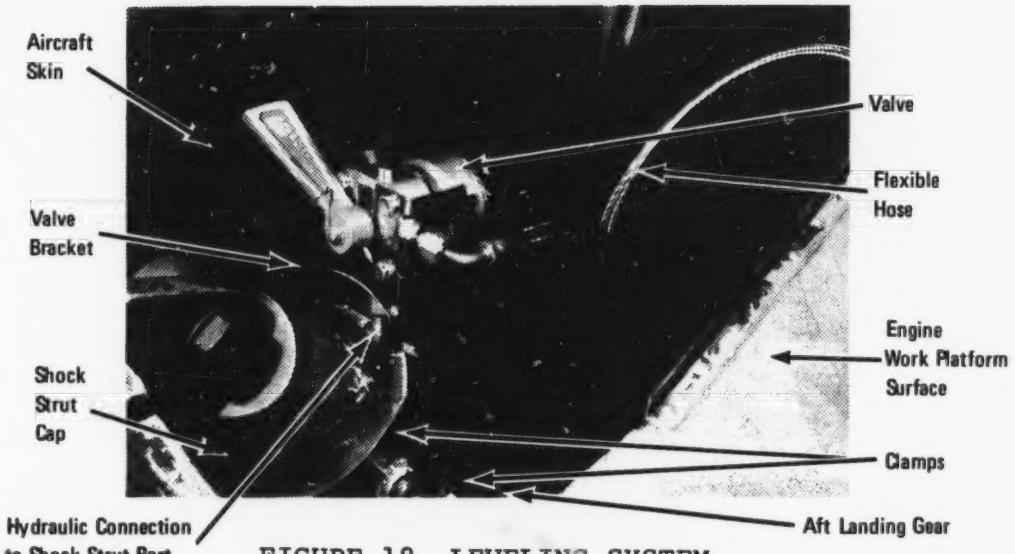

FIGURE 18. LEVELING SYSTEM, OLEO VALVE.

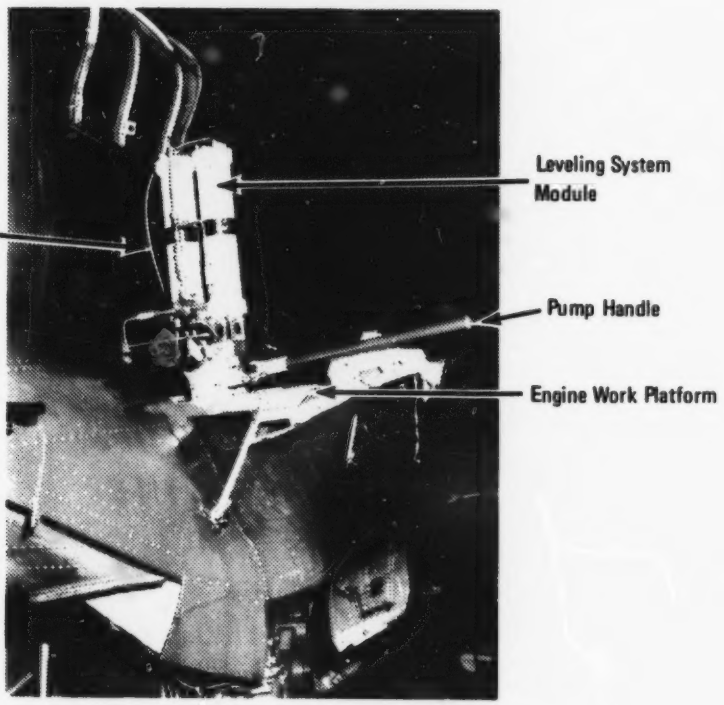

FIGURE 19. LEVELING SYSTEM, OPERATING POSITION.

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to the port, located at the top of the shock strut. The valve is supported by a bracket which is clamped directly to the landing gear shock strut cap. A flexible hose is used to connect the valve port to a port located at the top of the module (transfer cylinder), as shown in Figure 18. (See Figure 20 for the stowed position and Figure 21 for the operating position of the module; also see the Design Changes section for the redesign of the leveling system.)

The system stowage provisions consist of a set of various length, colored straps which are used to stow the barriers, the center roller channel assemblies, the ramp extensions, and the ramp and ramp extension support struts as shown in Figures 22, 23, 24, and 25.

A pallet claw is provided for the loading and unloading of 463L pallets utilizing the cargo winch. When in use, the pallet would be positioned on the ramp extensions. The pallet claw, attached to the winch cable, would be connected to the pallet lip on the aft side with the winch cable running forward, below the pallet. The winch would then be operated and the pallet drawn into the aircraft. Due to interferences between the pallet claw and the ballmats on the ramp, the claw was redesigned as specified in the Design Changes section.

A weight estimate is presented in Table 2.

A projected production system weight has been evolved and is included on the weight statement. These weights were established by reviewing the materials used in the demonstration system and substituting lighter materials where possible; for example, using a custom aluminum extrusion for the roller tracks in place of the bent-up sheet steel currently being used. The substantial weight reduction shown for the ramp system is based upon replacing the current ballmat arrangement with a roller track that may be repositioned to suit warehouse pallet loading.

The barrier system also permits substantial weight reductions due to material optimization; however, the most effective weight reduction is obtained by adding a barrier attachment to the aircraft overhead structure. The production system weight estimate assumes that the forward barrier would have such an attachment, while the aft barrier would be similar to the demonstration system.

HARDWARE FABRICATION

The initial contract required two shipsets of hardware; however, during the design phase of the program the contract was amended to add a further set. This additional system was procured by the Royal Air Force through ATL.

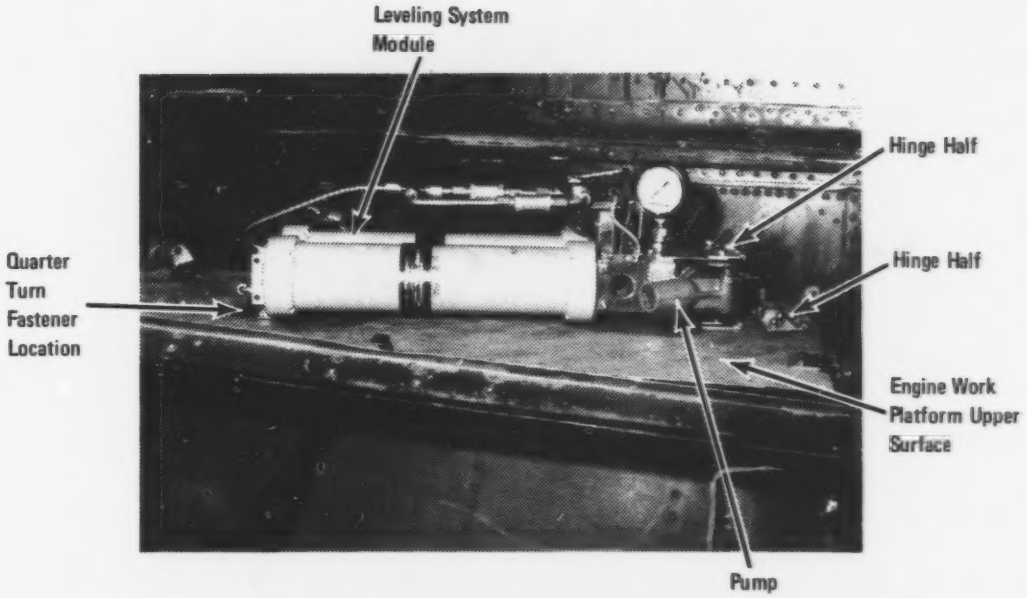

FIGURE 20. LEVELING SYSTEM, STOWED.

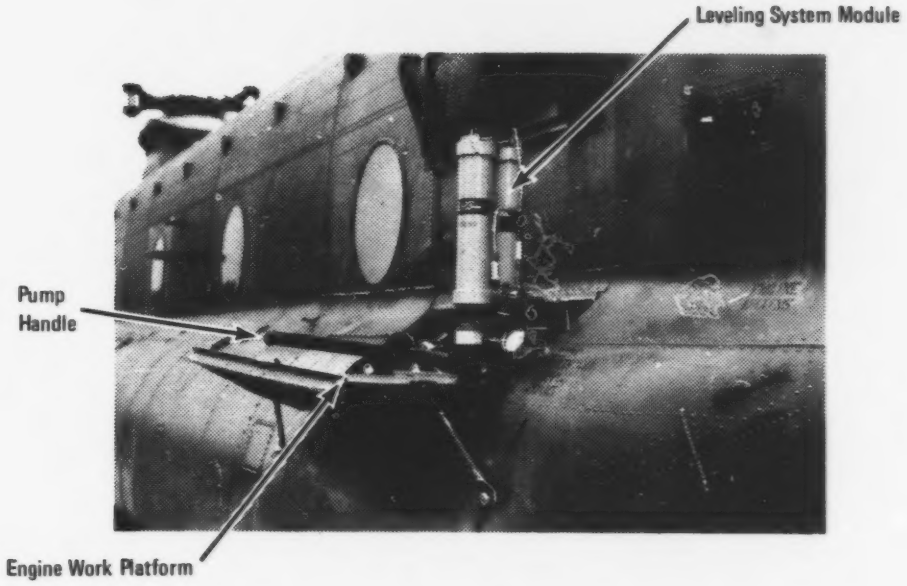

FIGURE 21. LEVELING SYSTEM, OPERATING POSITION.

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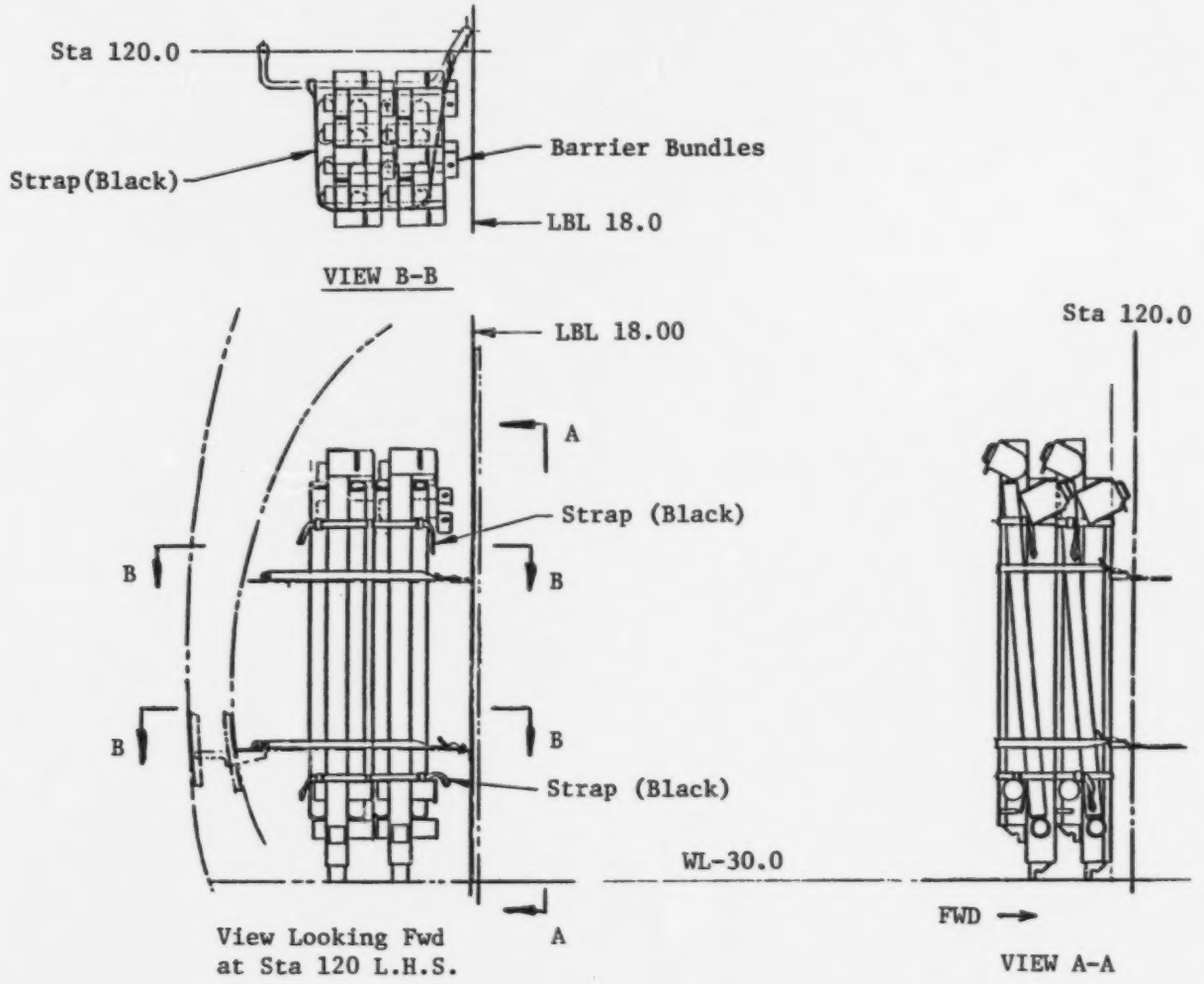

FIGURE 22. BARRIER STOWAGE.

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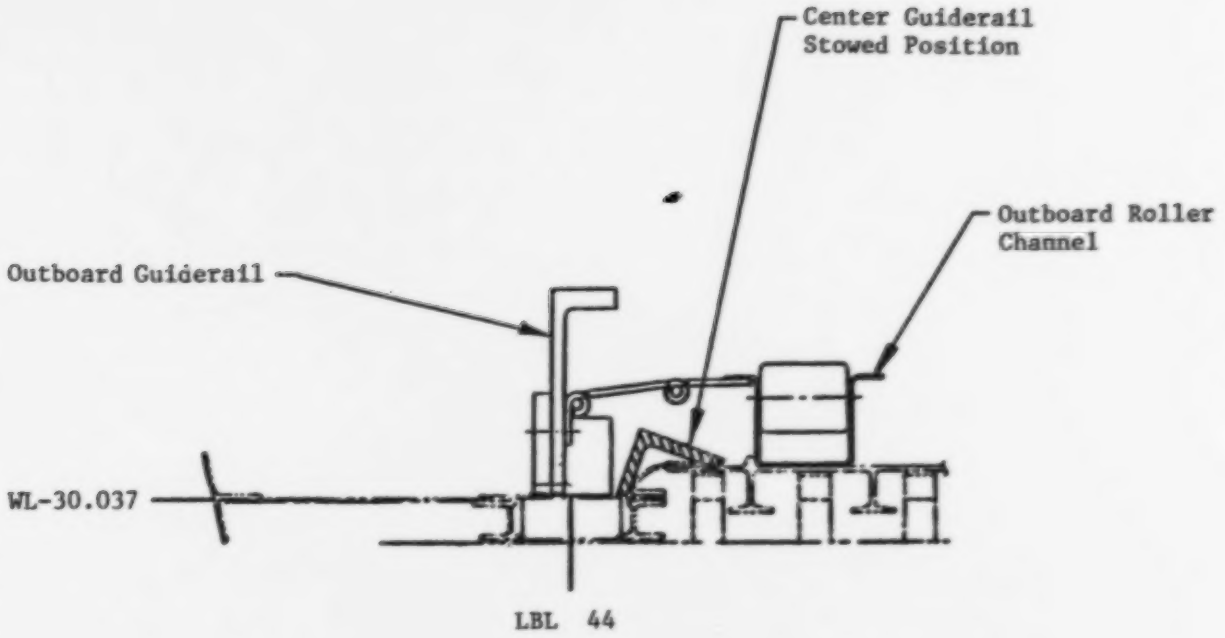

View Looking Fwd L.H. Side Shown
R.H. Side Opp.

FIGURE 23. CENTER GUIDERAIL STOWAGE.

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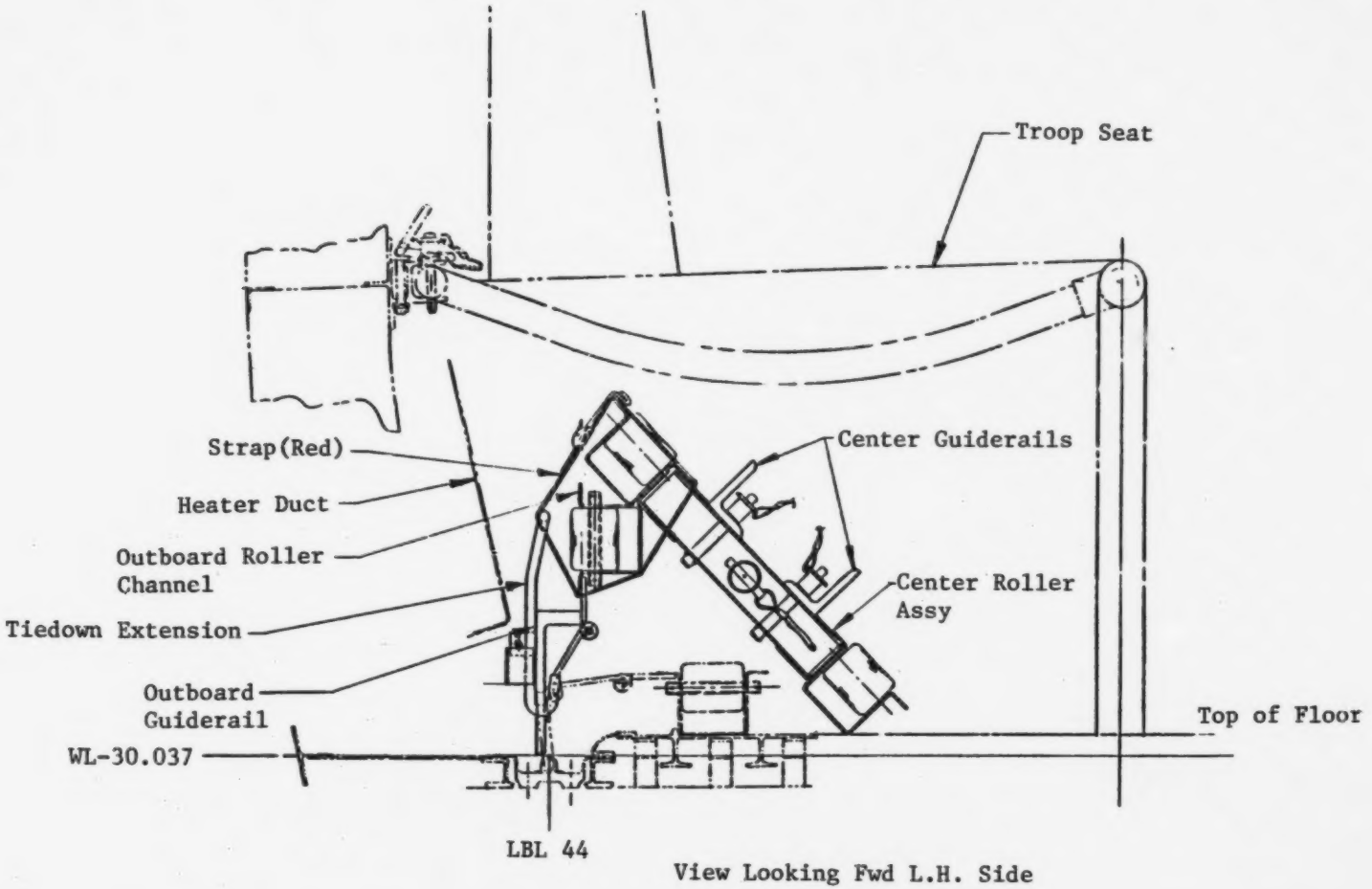

FIGURE 24. CENTER ROLLER ASSEMBLY STOWAGE.

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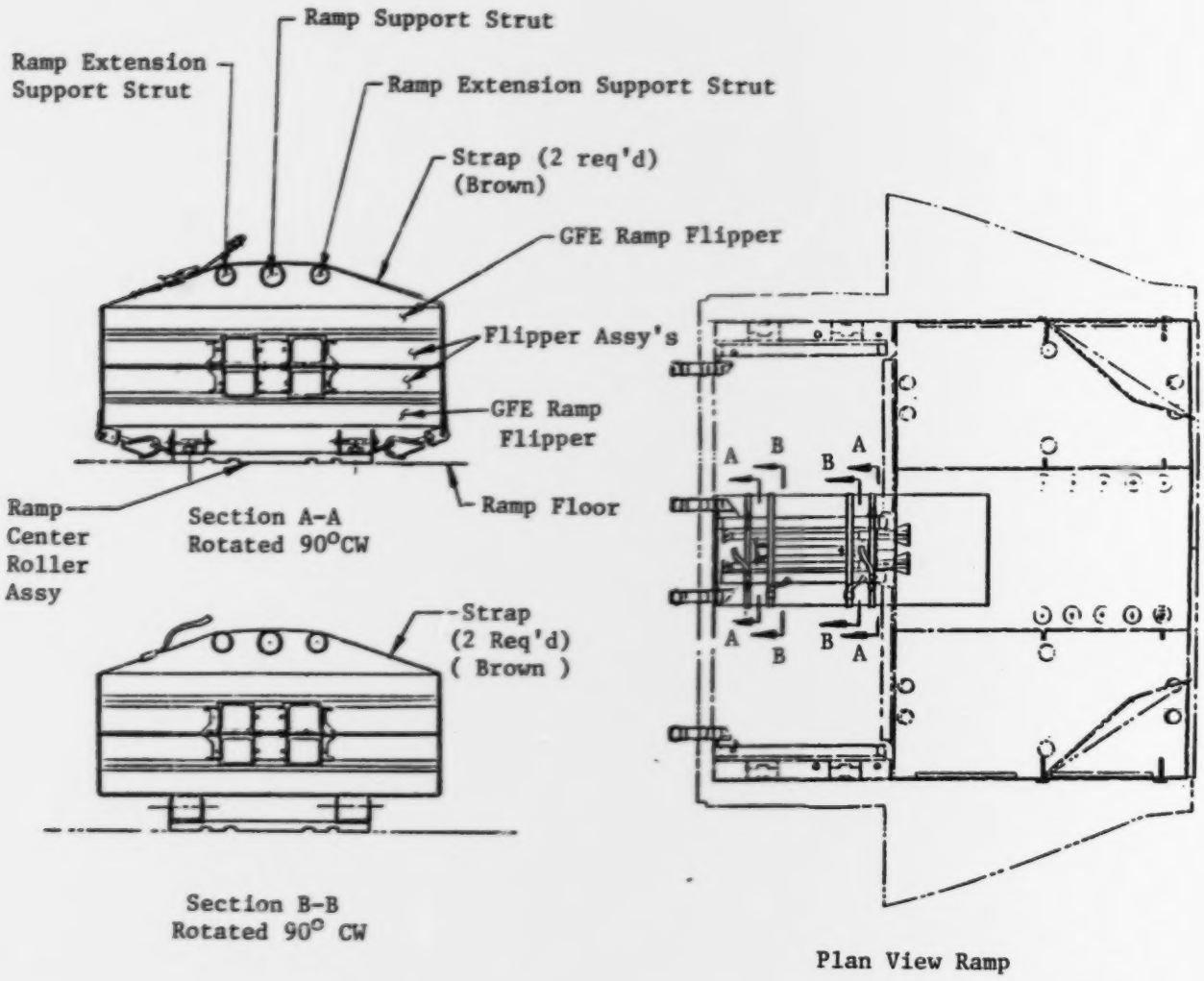

FIGURE 25. RAMP STOWAGE.

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TABLE 2. AICS WEIGHT ESTIMATE SUMMARY.
(Weight in Pounds)

SYSTEM	PROPOSAL ESTIMATE JULY '79	PRELIMINARY DESIGN ESTIMATE 3-20-80	DESIGN ESTIMATE 4-16-81	PROJECTED PROD. DESIGN
Cargo Floor	677	660	722	519
Ramp	676	460	405	124
Ramp Extension	55	140	146	66
Barrier	222	185	425	225
Leveling	50	50	48	43
System Stowage Prov.			13	13
Claw			3	3
TOTAL	1680	1495	1762	993

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In order to provide the hardware in an economic and timely manner, fabrication was subcontracted to suppliers with capability suited to this type of hardware.

Cabin System

All the hardware associated with the roller and guide system in the cabin was fabricated by Ludwig Honold Mfg. Co., 100 Locke Road, Edgemoor, Wilmington, Delaware.

Barrier Restraint System

The detail design and fabrication of the barrier system was undertaken by Davis Aircraft Products Co. Inc., Scudder and Woodbine Avenues, Northport, New York. Davis Aircraft manufactures a wide range of restraint and tiedown equipment.

The detail design was developed by Davis from layouts established at Boeing Vertol during the preliminary design phase. The barrier system stress analysis was performed at Boeing Vertol.

Ramp and Ramp Extension

All hardware for the ramp and ramp extensions was fabricated by Davis Aircraft Products to the Boeing Vertol detail drawings.

Leveling System

The principal components of the leveling system, the transfer cylinder and reservoir, were designed and fabricated by Loud Engineering and Manufacturing Company of California to Boeing Vertol specifications.

Assembly of the system, together with fabrication of all the associated brackets, was subcontracted to Delri Industrial Supplies, 1431 Chester Pike, Crum Lynne, Pa. Delri are suppliers of components and hydraulic subsystems for commercial applications. Delri also fabricated the pallet claw.

Roller and Shafts

The rollers and shafts used in the cabin and ramp were fabricated by Koehler Aerospace Inc., Brookridge Drive, Valley Cottage, N.Y. Koehler Aerospace specialize in nylon rollers for aircraft cargo systems.

FIT AND FUNCTION DEMONSTRATION

The requirement for a fit and function demonstration was established in the contract and a test plan prepared during the design phase. The test plan (Reference 3) detailed procedures for demonstrating the system handling 463L pallets and 40-inch x 48-inch warehouse pallets. The demonstration was conducted at Ft. Eustis on December 9, 1980, using a 'C' model Chinook. The results are detailed below.

An Advanced Internal Cargo Handling System designed for the CH-47 under contract DAAK51-80-C-0006, was installed in a 'C' model Chinook and demonstrated at Ft. Eustis, VA during the period of December 1 thru December 11, 1980. The installation and demonstration generally followed the procedures detailed in the test plan, D210-11667-1. The demonstration procedure was modified to suit the availability of personnel and dummy cargo, and to fit into the time slot for visiting observers.

The time period December 1 thru December 4 was used to fit the system into the aircraft. During this phase several minor discrepancies were discovered and reworked on site. Removal of the buffer boards on the aircraft proved to be difficult. Recognizing that this would probably apply to any aircraft being fitted with the system, the Contracting Officers Technical Representative (COTR) and Boeing Vertol agreed that the system would be revised for installation with the buffer boards installed. This was accomplished on site by the ATL facility. It was also recognized that the aircraft floor would have several coats of floor paint, preventing easy installation of the center roller rails; therefore the attaching holes were increased in diameter to allow for these variations. Other attachment holes were increased in diameter to ease installation.

Installation of the ramp system required new pivot and retention blocks for the moveable guide. These parts were also fabricated on site by the ATL workshop. Ramp and ramp extension support struts required length reductions for satisfactory fit.

Provision of attachment holes in the work platform for mounting the leveling system proved to be difficult due to the poor condition of these parts after they have been in service for some time. Potential clearance problems when stowing the system were identified; however, it was agreed that the system be installed and retained in the operating position to assess the functioning concept.

The ramp extension assemblies required excessive time to install and the roller track appeared to be too short, resulting in an

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3. Campbell, R. "Test Plan Fit and Function Demonstrations -Advanced Internal Cargo System" report number D210-11667-1, Boeing Vertol Company, May 1980.

excessive gap between the most forward roller and the ramp ballmats. This gap proved to be a problem during system demonstration.

The pallet claw, designed to pull 463L pallets into the cabin using the cargo winch, could not be used with the ramp system due to lack of clearance.

During this fit period, there was no opportunities to establish meaningful installation times. After the demonstration, times to remove the system were established.

The system was demonstrated on December 9, 1980. The morning was devoted to loading/unloading 463L pallets as follows:

1. The aircraft was leveled using the hydraulic leveling system. The system worked satisfactorily.

2. The forward barriers were installed at Sta. 160.

3. The center warehouse pallet guides were removed and located on the floor adjacent to the centerline rollers.

4. Using a 10-ton forklift, a 463L pallet was loaded onto the ramp extension. The pallet was ballasted to approx. 6,000 lb. The pallet was man-handled forward into the fuselage by four men.

   The lead-in guides were subjected to high loads due to poor positioning by the forklift and had deep score marks on the guide surface.

   Transferring the pallet across the ballmat surface required more effort than the fuselage roller system.

   The pallet was positioned against the forward barrier.

   The second 463L pallet, loaded to approx. 3,500 lb., was installed by the forklift and installed behind the first pallet.

5. The aft barrier was to be installed; however, protruding bolt heads inside the roller channels prevented the barrier vertical post engaging at this location. To demonstrate the operation, the pallet was moved aft 12 inches and the barrier successfully installed.

6. The leveling system was used to revert the landing gear to the operational configuration. The system operated satisfactorily.

7. The leveling system was used to raise the aircraft for cargo unloading. The system operated satisfactorily.

8. The aft barrier was removed.

9. A third, unloaded 463L pallet was installed to demonstrate the aircraft's ability to take three 463L pallets. The ramp was closed. There were no problems in installing the three 463L pallets.

10. The ramp was lowered and the unloaded pallet and the second loaded pallet were removed using the forklift.

11. The leveling system was used to lower the fuselage and the ramp lowered to the ground; the ramp extensions also touching the ground.

12. The cargo winch hook was attached to the pallet load and the pallet moved to the ramp, the pallet movement being controlled by the cargo winch. Manual effort was required to initiate and sustain pallet movements down the fuselage.

13. The pallet was moved until the aft edge was contacting the ground. A tow tug then moved the aircraft forward until the forward edge of the pallet was over the aft edge of the ramp. At this point the tug was pulling the pallet along the ground as there were now no rolling elements under the pallet due to the excessive gap between the ramp and ramp extension.

    The pallet was then anchored to the forklift truck by a series of tiedown straps and the tug moved forward. Eventually the pallet was pulled off the ramp extensions, however, and the ramp extension roller sections were damaged and the roller section attachment to the extension was destroyed.

    This operation of off loading 463L pallets without ground support equipment demonstrated the need to revise the ramp extension to provide rolling elements at the most forward position.

The afternoon of December 9 was devoted to loading and unloading warehouse pallets as follows:

1. The aircraft was leveled using the leveling system and the center warehouse guides were installed.

2. The forward barrier was installed at Sta. 160 in the warehouse pallet mode, i.e., with centerline straps installed.

3. Warehouse pallets, loaded to 1,500 lb., were installed, one on the RH side and one on the LH side of the fuselage. During this operation, care had to be taken to ensure the pallets did not impact the ramp aft edge when leaving the ramp extension. The ramp was raised slightly to ensure

satisfactory movement. A reduction in the gap between ramp and extensions will eliminate this potential problem. Moving the pallets over the transfer balls required high effort; there was no difficulty in moving the pallets on the fuselage rollers.

Vertical restraint straps were installed.

A second pair of pallets, unloaded, were then installed; a third pair, again loaded to 1,500 lb., were installed, completing the simulated load of six pallets, three each side of the fuselage.

4. The aft barriers were installed in the warehouse pallet mode. Installation of the aft barrier was quick and presented no problems. The barrier was snug against the aft load.

5. The RH aft barrier was removed and the aft warehouse pallet unloaded from the RH side. There were no problems in unloading with the forklift.

6. The fuselage was lowered to its operating position and the ramp guides moved to their inboard positions.

7. The remaining RH side pallet, loaded to 1,500 lb., was moved down the fuselage, using a tiedown strap to control the movement. The pallet was manually controlled down the ramp and onto the ground. There were no problems.

8. Having demonstrated unloading with and without ground handling equipment, the RH forward barrier was removed to demonstrate an aircraft loaded on the LH side of the fuselage. Although there were no troop seats fitted to this aircraft, there did not appear to be any problems in having the RH side troop seat down for mixed passenger/cargo operations.

9. The LH aft barrier was now removed and the pallets were unloaded. The demonstration was now complete.

Subsequent removal of the system from the aircraft took the following times:

Removal of one outboard guide/rail - 21 minutes, one man.

Removal of center section rail assemblies - 6 minutes, one man.

Removal of ramp system - 10 minutes, two men.

Removal times for the ramp extension and leveling systems were not recorded as these areas are subject to design changes.

The following section details the design and hardware changes required to provide useable systems.

Revisions to the AICS Drawings and Hardware Required.
Fuselage System SK 28497

1. Lateral load bumper pads -25 require .19 inch removed from outboard face. (12 places)

2. Holes in -50 & -60 channels for centerline ring attachments to be increased from 1.03/1.09 dia to 1.125/1.187 dia. (32 places)

3. Rework -23 centerline replacement rings to ensure correct radius. (1.08 inch)

4. Extend notch in forward center guide, -57 & -58. For forward notch extend forward 1.0 inch. For aft notch, extend aft .75 inch.

5. Center guides -57, -58, -71, -72, -77, -78 to have attachment holes increased in dia from .379 to .421.
.375

6. Channel splice plates -31, -32, -73, -74, -85, -86 require .13 removed from lower edge and pin hole dia increased from .4425 to .460.
.4375 .453

7. Barrier quick-release pins to be revised for outboard locations; head of existing Q/R pins too large. Need to make pin from headed MS 20392 pin and retainer. Engineering required.

.229

8. Outboard replacement tiedown rings have .218 dia holes for localing pins. Hole needs to be reduced in dia to be less than .20 inch. Possible alternatives: a) fill hole with weld and redrill. b) use eyelet similar to AN 240-3 to sleeve hole. Engineering required.

9. Heads of attachment bolts through sides of BL.5 roller channels prevent installation of aft barrier. A flush situation is required. Need to investigate alternate attachments. Engineering required.

10. Provide retention for all hinge pins. Pins may be peened.

Ramp System SK28500

1. All wood panels require paint.

2. Wood panels need notching to match metal frame. Engineering required.

3. Guide pivot and retention blocks, -36, need to be revised to ensure guide will match holes inboard and outboard. Attach holes in -31 & -32 guide rail may need relocating. Consider slotting holes for assembly adjustment. Engineering required.

4. Attachment hole thru outer ballmat panels not required.

5. Forward corner of roller channels require a chamfer, approx. .75 x .75 (4 channels) Engineering required.

6. Forward section of outboard roller interfere with ramp bolt-head. Clearance holes required. Engineering required.

7. The articulated attachment of the roller sections to the guide rail allows roller to tilt when edge-loaded. Weld inboard hinge joint. Correct angle for welding to be determined by engineering. Engineering required.

8. Ramp prop requires larger foot-print. Weld or rivet 8" x 8" plate, 3/16" thick, to existing foot.

9. Ramp prop requires length reduced and additional adjustment hole. Engineering required.

10. Hinge pins to be retained.

11. Guide assemblies, -38 & -39, require hard surface on inboard face. Strip paint, hard anodize wear face only, bake dry film lube this surface. Refinish. Engineering required. (This item not accomplished due to the cost being beyond the resources of the program.)

Ramp Extension SK28501

1. Design to be reviewed for ease of installation. As a minimum, upper sheet will have access holes for attachment bolts.

2. Aft attach holes to be relocated forward to keep hardware on parallel portion of flipper.

3. Screws attaching non-skid surface to be flush.

4. Roller channel, -9, required to be longer and have additional roller at forward edge. Review design for requirement for articulated roller.

5. Material for roller channels to be steel.

6. Chamfer required on corners of channels.

7. Rollers to be mounted higher in channels. Alignment of rollers with ramp system to be reviewed.

8. Prop assembly requires to be revised. -14 extension to be increased in diameter to fit over the -13 base.

9. Base to have footprint increased to 8" x 8".

10. Length of prop to be reduced and additional adjustment hole added.

11. Attachment of roller to the base assembly is inadequate. Engineering to review in conjunction with items 4, 5, 6, and 7.

All the above items require engineering action.

Fuselage Leveling System SK28499

1. Existing design for mounting hydraulic package on work platform is inadequate. Work platform is not rigid enough for pumping. Engineering to provide a module for mounting on the airframe skin within the landing gear bay. Airframe to have permanent attachments installed.

2. Valve mounting on strut does not permit the work platform to close. Engineering to revise.

3. Both system valves require markings for lever positions.

Barrier System Davis FDK-7430

1. Sleeve through vertical stantions require larger I.D. for ease of horizontal tube installation.

The preceding fit and function demonstration resulted in the generation of The Installation and Operation Procedures, Advanced Internal Cargo System (Reference 4). This document contains all information required to install and operate the system.

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4. Ednie, C. "Installation and Operation Procedures, Advanced Internal Cargo System, CH-47 Helicopter," report number D210-11838-1, Boeing Vertol Company, May 1981.

DESIGN CHANGES

During the Fit and Function Demonstration at Fort Eustis, minor interferences were encountered and eliminated by increasing certain clearance holes and cutout sizes. It was also determined that the leveling system, the ramp extensions, and the pallet claw warranted additional design effort.

The pallet claw was redesigned, as shown in Figure 26, to reduce the amount of clearance required between the bottom surface of the 463L pallet and the upper surface of the ballmats on the ramp. The redesigned claw is used in the same manner as the original claw except that it is articulated, with a roller at the trailing end. It requires that there be a surface, under the roller, to provide a reaction point to distribute the load generated in the claw during the cargo loading or unloading process.

The ramp extensions were redesigned to eliminate the requirement to drill seven holes through each GFE ramp flipper and assemble the loose pieces, which comprised each ramp extension, in the field. The redesigned extensions are completely assembled and ready for installation. The extension is connected to the GFE ramp flipper by sliding the ramp extension on top of the GFE ramp flipper and attaching with a tube and ball lock pin as shown in Figure 27. The flip-over feature, which existed in the original design, is eliminated due to the ease of removing and installing the redesigned extensions.

The leveling system was repackaged to eliminate the requirement of drilling through and mounting on the engine work platform. When mounted on the platform essential working space was occupied by the module and would ultimately result in damage to the module. Also, due to the play in the work platform support struts, the pumping action required to transfer the fluid to extend the oleo resulted in a strut failure at the hinged joint at the work platform.

The repackage consisted of modularizing the existing components on to a sheet metal panel, attaching the module to the aircraft skin using two work platform door latch keeper bolt locations, and drilling and picking up three additional bolt locations through the aircraft skin as shown in Figures 28, 30, 31 and 32.

A hydraulic connection is made to the aft landing gear in a similar manner as the original design, except that the bracket has been redesigned to increase the clearance between the valve and the work platform door when closed. Also a bent tube connection, in lieu of a straight tube, is provided between the landing gear port and the valve port to allow for spring action adjustment at installation, thus eliminating the need to trim as shown in Figure 29.

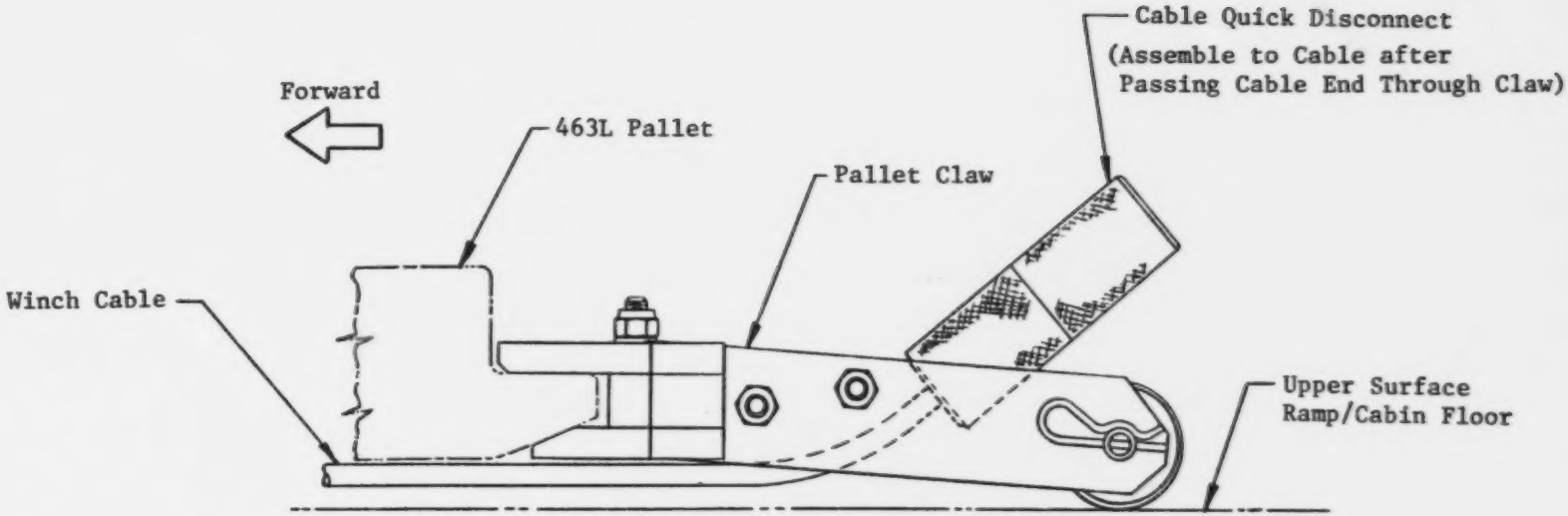

FIGURE 26. PALLET CLAW.

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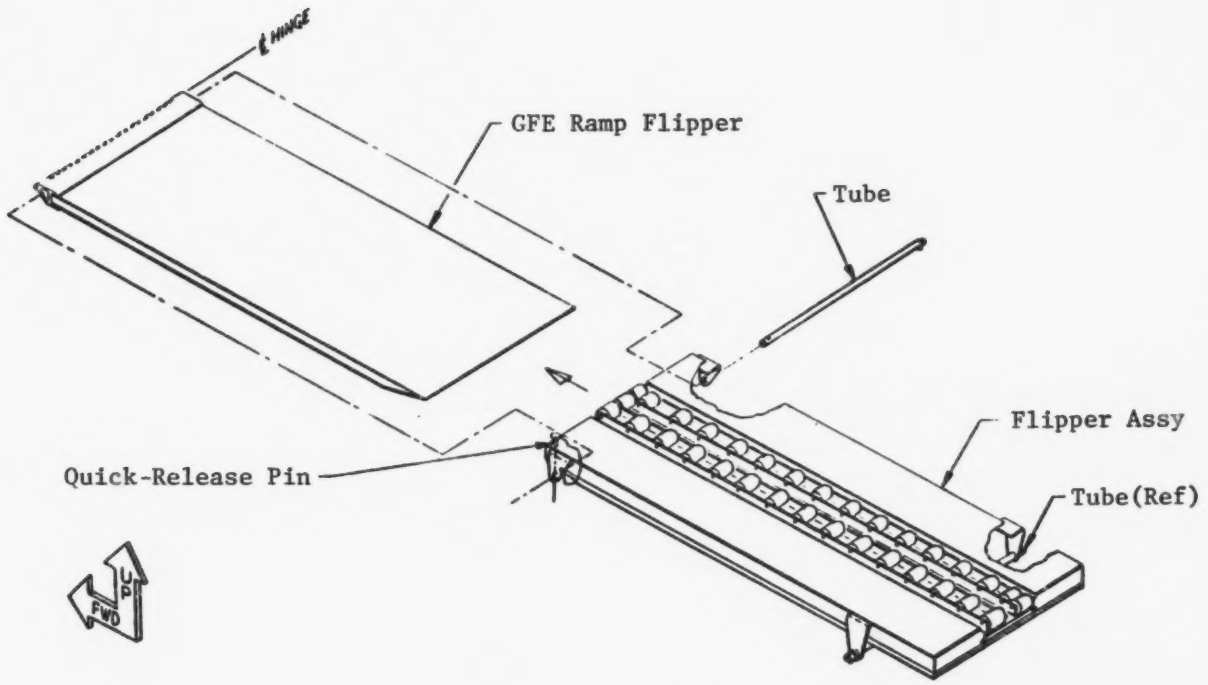

FIGURE 27. RAMP EXTENSION.

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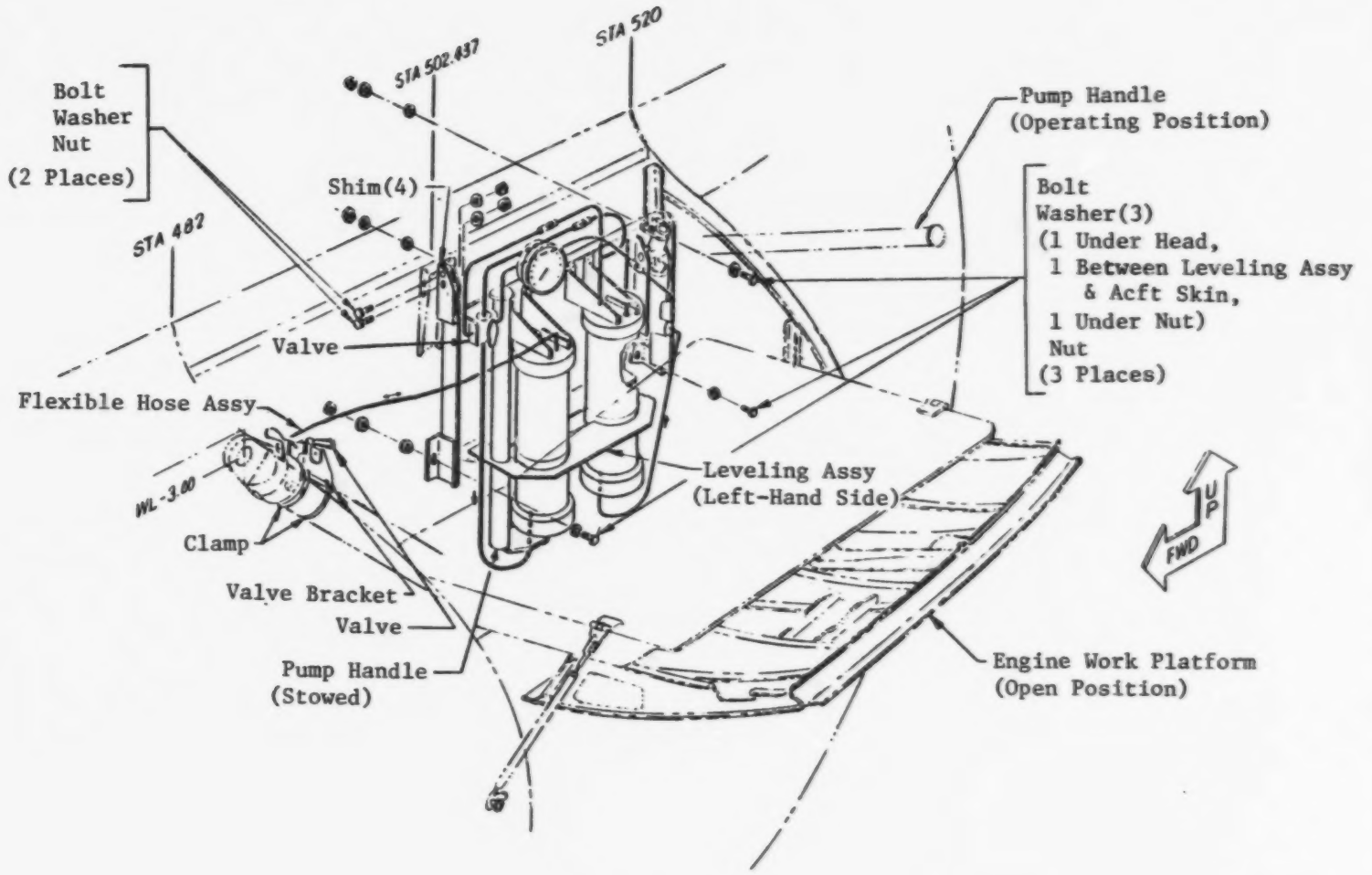

FIGURE 28. LEVELING SYSTEM

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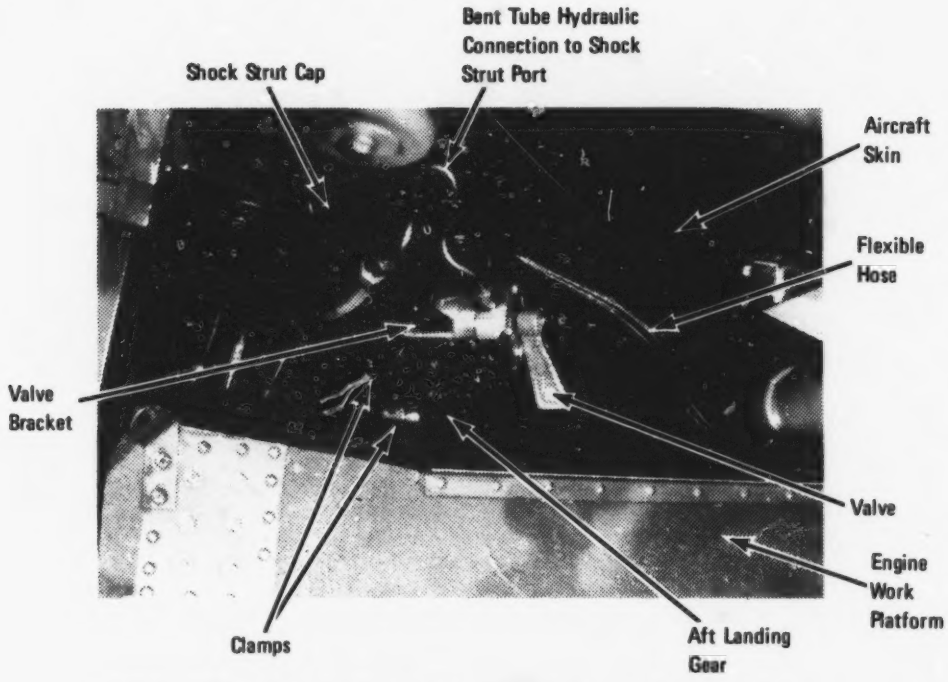

FIGURE 29. LEVELING SYSTEM, OLEO VALVE.

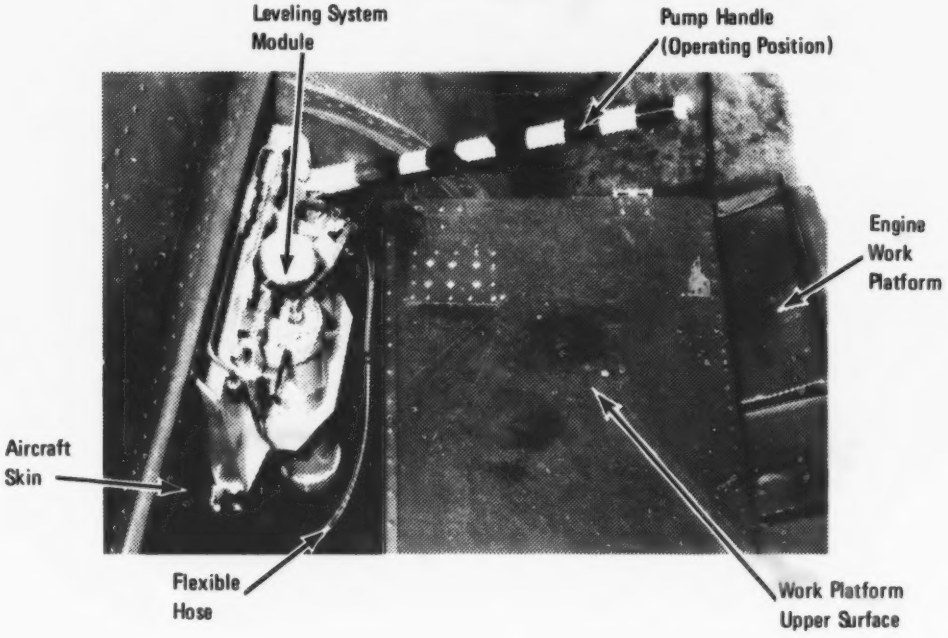

FIGURE 30. LEVELING SYSTEM, INSTALLED.

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FIGURE 31. LEVELING SYSTEM, INSTALLED.

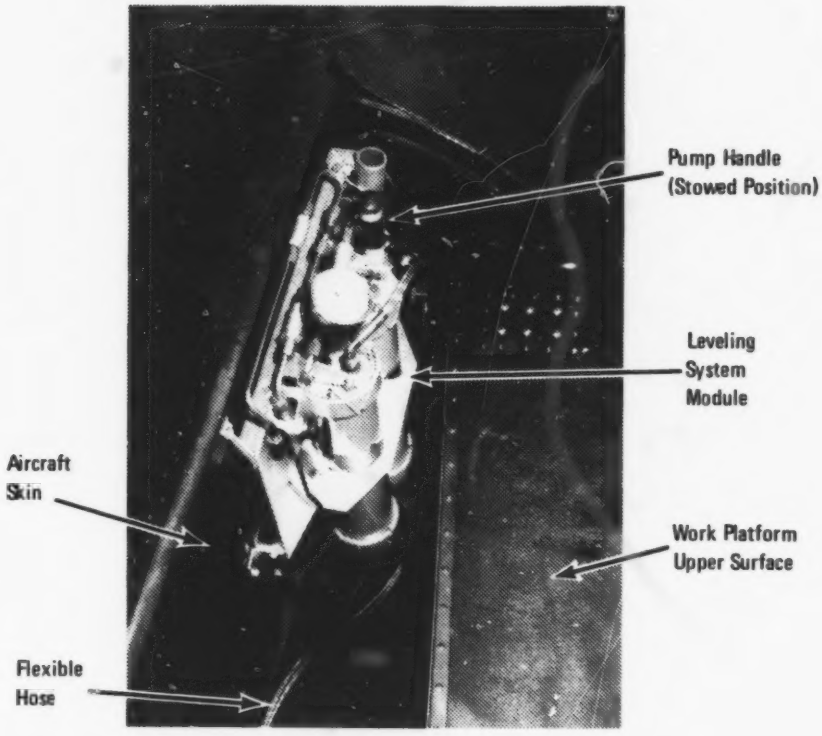

FIGURE 32. LEVELING SYSTEM, INSTALLED.

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INSTALLATION IN YCH-47D AIRCRAFT

The complete Advanced Internal Cargo System was installed in a YCH-47D aircraft at Fort Eustis on May 29/30, 1981. During the installation procedure several areas of interference were brought to light which had not previously been identified.

In the cabin portion of the installation, two problem areas were identified. Both problems involved the BL0 roller channel assemblies.

When attempting to install the barrier stanchions in the roller channels at STA's 344 and 356, the foot of the stanchion could not latch on the barrier attachment locations due to interference with rivets. The rivets were removed and installation was completed. It was determined that the loss of these rivets did not constitute any significant reduction in strength, therefore they were not replaced.

At approximate STA 367 along the RBL5.25 roller channel the lanyard attachment interfered with the installation of the stanchion. It was relocated to clear the stanchion.

Of the sixteen locations, where the center roller channels attach to the tiedown rings, approximately eight tube assemblies were replaced by tube assemblies with smaller outside diameters, due to interferences. The replacement tube assemblies were fabricated on site. Of the eight, three could not be installed due to a patch doubler on the floor below one roller channel. Five were determined to be too tight to be acceptable.

In the ramp portion of the installation two holes had to be slotted, along the right-hand guiderail only, in order to install all of the attachment screws.

In the leveling system portion of the installation, the left side was completed and checked for fit and function. All worked properly. The right side was checked and fit properly. The functional check uncovered a leak problem caused by either a faulty valve port or improper assembly procedure. No spare parts were available so both the left- and right-hand installations were removed from the aircraft.

During installation of the barriers, difficulty was encountered in positioning the aft barriers in the roller channels at the barrier attachment location. The end caps were removed from one end of each lower cross tube of each aft barrier. The barrier was then installed with ease. See Figure 13 for end cap and lower cross tube locations within the barrier assembly.

CONCLUSIONS

The initial fit and function demonstration and the installation of the system into a YCH-47D aircraft has shown that the system can fulfill the basic requirements of the program.

The limited experience gained has suggested several areas where significant improvements could be made to reduce weight, reduce cost, improve restraint, and provide more durable hardware.

In a production design, the ramp system could be redesigned to eliminate the requirement for transfer ballmats on the aft two-thirds of the ramp floor. Roller channels would be provided along the full length of the ramp floor. Each roller channel would be attached directly to the ramp floor with quick-release fasteners at both the forward and aft edges. The outboard roller channels would have integral side guiderails. The inboard roller channels would be attached to each other with five pivoting links. Six transition rollers would be located at the aft end, while two transition rollers would be located between the first and second pivoting links (from the forward edge.) The transition rollers between the ramp and cabin floors would now be permanently affixed to the cabin roller sections.

In the 463L pallet mode the roller channels would be positioned on the ramp floor in line with the cabin section rollers, as shown in Figure 33, for loading and unloading.

In the warehouse pallet mode, the left-hand outboard roller channel and guiderail is pivoted, about its forward attachment, to its inboard attachment location along the aft edge of the ramp. The inboard roller channels are pivoted, about their forward attachments, to their right-hand outboard attachment locations along the aft edge of the ramp. This forms a diagonal roller bridge between the ramp extension rollers and the left-hand cabin section rollers, as shown in Figure 34, for the loading of the left side of the aircraft. The right side of the aircraft would be loaded in a similar manner, by pivoting the right-hand outboard roller channel to its inboard attachment location and the inboard roller channels to their left-hand outboard attachment locations.

During the loading process, the warehouse pallets would be positioned on the ramp extensions, then moved forward until approximately one-half of the pallet rests on the ramp rollers. The pallet would then physically be pushed forward and around the corner until it rests completely on the ramp rollers. In a similar manner it would then be moved into the cabin.

In a production system, the ramp extensions would remain as a removable sleeve design but the requirement for wood shims and spacers, and the anti-skid material would be eliminated due to the readily removable feature of the design.

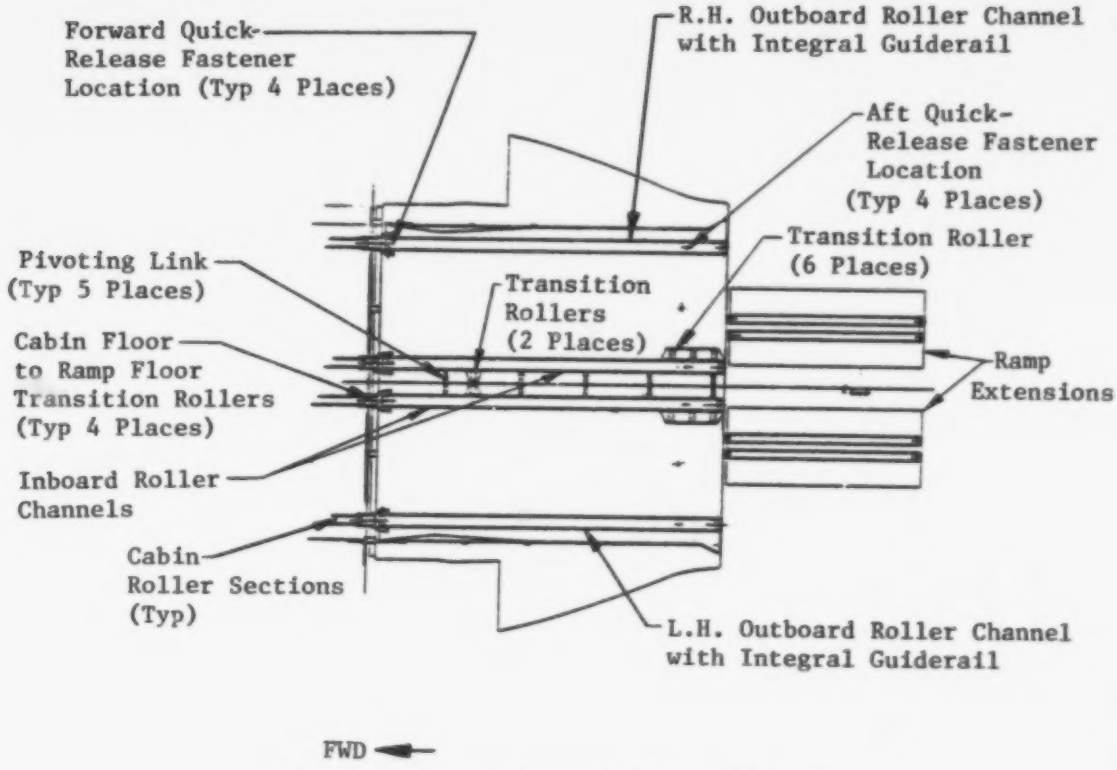
Forward Quick-Release Fastener Location (Typ 4 Places)
R.H. Outboard Roller Channel with Integral Guiderail
Aft Quick-Release Fastener Location (Typ 4 Places)
Transition Roller (6 Places)
Pivoting Link (Typ 5 Places)
Transition Rollers (2 Places)
Cabin Floor to Ramp Floor Transition Rollers (Typ 4 Places)
Ramp Extensions
Inboard Roller Channels
Cabin Roller Sections (Typ)
L.H. Outboard Roller Channel with Integral Guiderail
FWD

FIGURE 33. RAMP CONCEPT-463L PALLET MODE.

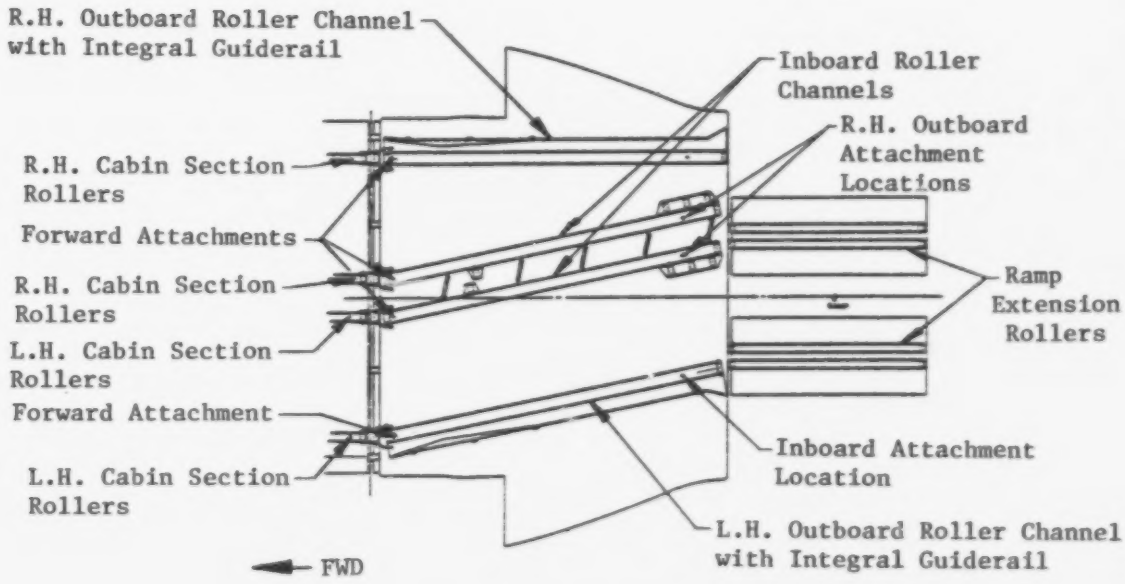

FIGURE 34. RAMP CONCEPT-WAREHOUSE PALLET MODE.

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One of the basic requirements of the contract statement of work is for the capability to taxi dump warehouse pallets. This would be accomplished by positioning the inboard roller channels along the centerline of the ramp and the left-hand and right-hand outboard roller channels to their respective inboard attachment locations, as shown in Figure 35, for unloading either the left- or right-hand cabin section rollers.

In the stowing of the ramp flippers and ramp outboard roller channels, in a redesigned system, Figure 36 shows the outboard roller channels pivoted inboard and the ramp extensions removed and stowed on top of the rollers. Another approach is to leave the outboard roller channels in their outboard position and pivot the aft portion of the guiderails inboard. The sleeves could then be removed from the ramp flippers and stowed separately inside the aircraft. The ramp flippers could then be stowed by flipping over onto the ramp floor between the ramp roller channels in the same manner as they are presently stowed. Further investigation would be required to determine which course of action would best facilitate use in the field.

A redesign of the barrier system for reduced weight and better load distribution would require that hard points be added to the ceiling structure to share flight and crash loads with the floor structure.

The forward barrier would have a left-and right-hand side consisting of rigid stanchions for flight loads only, while KEVLAR webbing and straps with integral attenuator units would handle crash loads, as shown in Figure 37. Crash loads could be attenuated to 7G. Two positions for attaching the forward barrier would be supplied. The CG limitations of the aircraft would determine which location was selected.

The aft barrier would have a left-and right-hand side consisting of KEVLAR webbing and straps with lever type tensioning buckles. A multi-position feature, to accommodate various load sizes, would be provided on the floor by attachments in the floor roller tracks. In the ceiling, four longitudinal KEVLAR straps, with rings at 20-inch intervals, would be provided as the upper attachment for the aft barrier, as shown in Figure 37.

The redesign of the barrier system would maintain the capability of carrying a mix of cargo and passengers. The left-hand side of the aircraft would be reserved for cargo. Attenuated side barrier nets would be provided, attaching to the seat rail and BL0 floor attach points, for lateral restraint. The seats along the right-hand side of the aircraft would remain available for use by troops as shown in Figure 38.

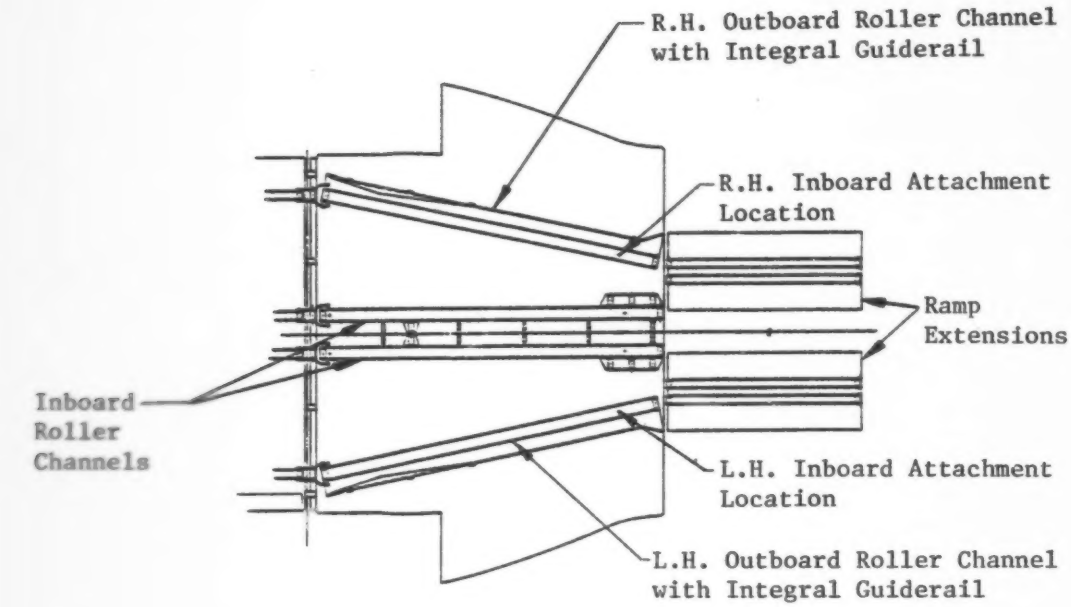

FIGURE 35. RAMP CONCEPT-TAXI DUMP MODE.

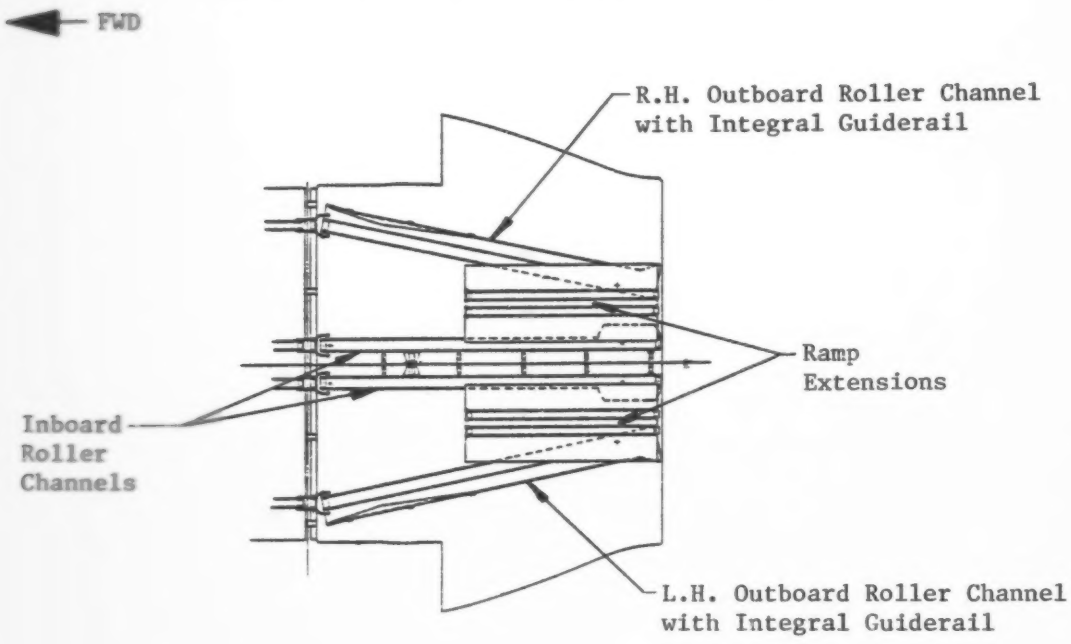

FIGURE 36. RAMP CONCEPT-SYSTEM STOWED.

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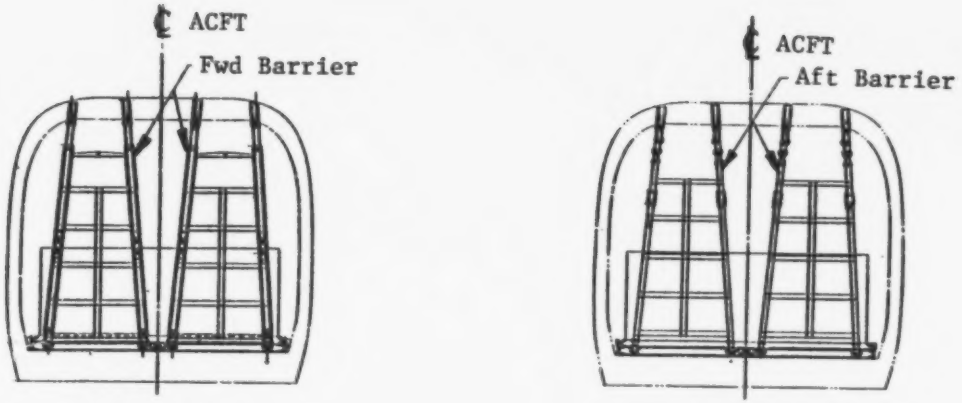

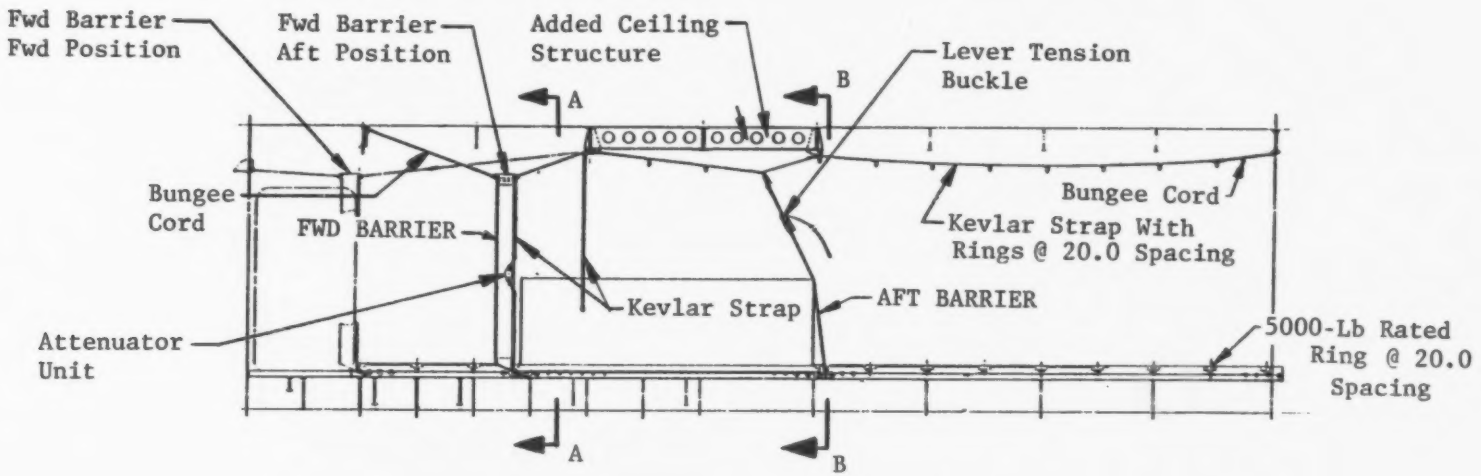

LOOKING INBOARD L.H. SIDE AIRCRAFT

FIGURE 37. BARRIER SYSTEM CONCEPT.

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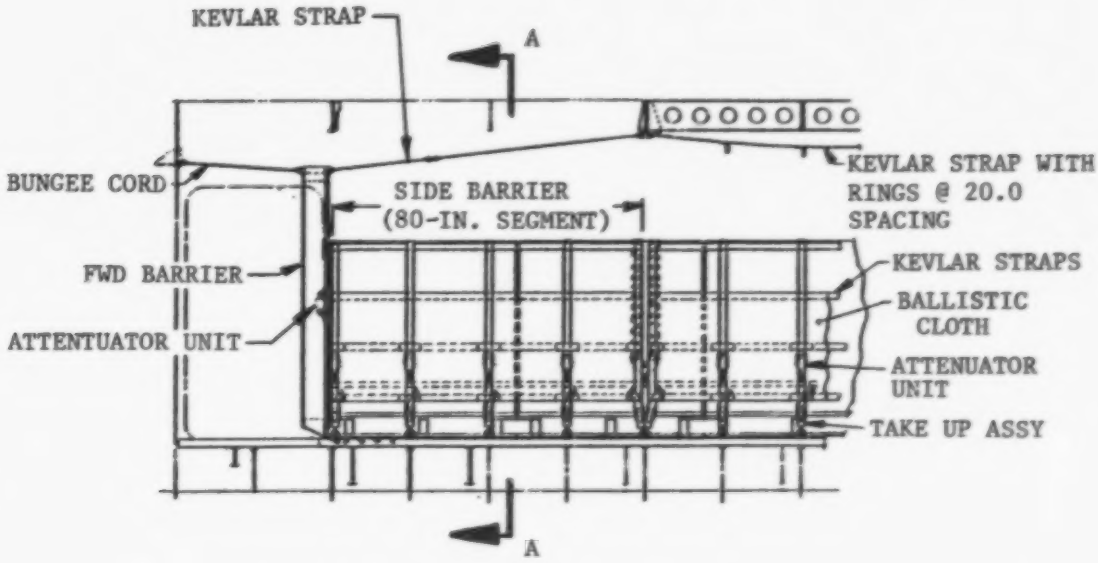
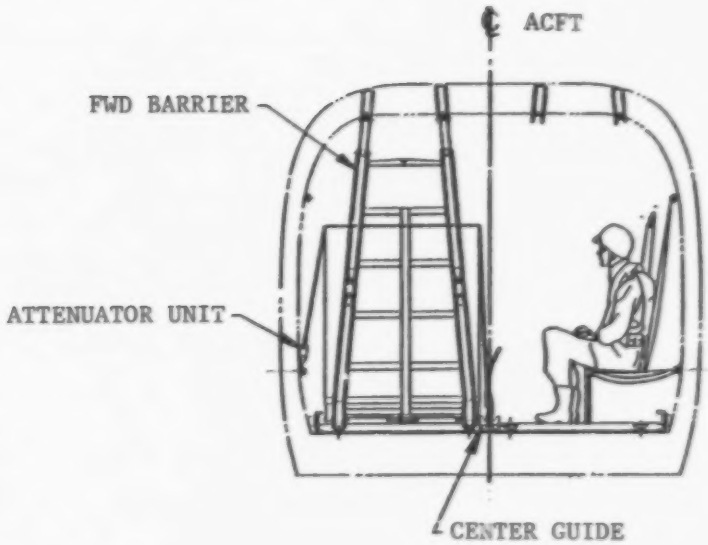


VIEW LOOKING INBD L.H. SIDE AIRCRAFT



SECTION A-A
LOOKING FWD

FIGURE 38. LATERAL NET CONCEPT.

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RECOMMENDATIONS

Based on the results of this effort, it is recommended that:

1. A prototype ship set of a redesigned ramp system be fabricated for demonstration and test in conjunction with the existing cargo handling system.

2. In a production system, the barriers be redesigned.

3. A study be conducted to review the need to accommodate warehouse pallets unless assembled to a 463L pallet. A system primarily directed to accommodating the 463L pallet system would eliminate the cabin centerline guide system, the barrier restraint system and the articulation of the ramp roller system. By retaining the roller track spacing as currently designed, individual warehouse pallets could be accommodated by taking care, in installing, to ensure the pallet is held against the outboard guide rail and providing sufficient restraints to take care of forward and lateral loads. Additional fittings would be required to act as forward and aft stops for the 463L pallet, capable of passing the longitudinal inertia forces into the roller tracks.

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1. Tansey, John F. "CH-47 Helicopter Internal Cargo Load and Restraint System Mock-up Study." Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, November 1978, USARTL-TN-32, ADA064207.

2. Dennis M. "Stress Analysis, Advanced Internal Cargo System, CH-47 Helicopter," report number D210-11839-1, Boeing Vertol Company, May 1981.

3. Campbell, R. "Test Plan Fit and Function Demonstrations - Advanced Internal Cargo System" report number D210-11667-1, Boeing Vertol Company, May 1980

4. Ednie, C. "Installation and Operation Procedures, Advanced Internal Cargo System, CH-47 Helicopter," report number D210-11838-1, Boeing Vertol Company, May 1981.